The Journal
OF THE
Royal United Service Institution.

Vol. VII. 1864. No. XXIX.

LECTURE I.

Friday, April 17, 1863.

Colonel P. J. YORKE, F.R.S., in the Chair.

ON THE RECENT PROGRESS OF THE MILITARY SCIENCES.

By G. R. Burnell, Esq., C.E., F.G.S., F.S.A.

The great changes which have been effected in all branches of applied sciences of late years, as might naturally have been expected, have been eagerly adapted, by the parties who are entrusted with the defence of the nation, to the exigencies of their particular branch of the public service; and so great have been the alterations made in the arts of attack and defence, that it becomes necessary for the student to watch carefully the directions in which the intellect of the age is turning. Long peace has produced this useful effect; and men's minds not being called upon to supply the immediate wants of the day, have been directed to the best means of perfecting the weapons, and the processes necessary for war, until the whole science has been so entirely changed, as to call for a new statement of the means at our disposal. This, gentlemen, I have been engaged to lay before you, with reference especially to the changes introduced in the course of last year; and though, in no sense a military man, I venture to address you at present, because I believe that you will excuse any shortcomings of which I may be guilty, for the sake of the abstract importance of the modifications of the physical sciences, which I shall have occasion to bring under your notice.

The first condition in any review of the kind I have undertaken, has been to adopt a classification, so as to group the various discoveries under the same heads, and to allow them reciprocally to cast light one

upon another. This will be best done, in our case, by dividing our subject into two great classes—the naval and the military—and by discussing the various modes in which they have lately been treated; and this course seems to be the more desirable, because the recent changes, in respect to the means of attack and defence, seem to resolve themselves into two great classes, which are respectively appropriated to the sea and land services. The modifications introduced by modern gunnery in the building of ships, the changes in the outlines of vessels by the introduction of steam, and latterly the utter revolution in the construction of vessels, effected by the experience of the last few years, have led to a change in the science of naval architecture, as radical as the one effected in military affairs by the substitution of the polygonal system of fortification, the substitution of the rifle for Brown Bess, and the introduction of the Armstrong and Whitworth guns. It is, of course, difficult to establish a rigorous division of the kind proposed, for the two branches of the service are so closely connected, that in speaking of one, the other must come under notice; but, as far as possible, I propose to call your attention on this occasion, to the changes recently effected in the naval service.

The events of the Russian campaign in 1854 and 1855, had proved the necessity for some new method of engaging the fortifications which might be erected on land, by the failure of the attack of the 7th October, 1854, upon Sebastopol; and by the success of the bombardment of Kinburn on 18th of October, 1855. The comparative inefficiency of the great fleets sent with such boasting to the Black Sea and to the Baltic, was evidently to be attributed to the superiority which the means of defence had then established over those of attack; and the fleets of the Allies were condemned to inactivity, because they were unable to cope with the granite-faced batteries of Cronstadt and Sebastopol. Great credit is due to the Emperor of the French for perceiving the cause, and for at once suggesting the remedy for this state of things, by the construction of the floating batteries, coated with iron, which did such good service at Kinburn, where the "Devastation," "la Tonnante," and "la Lave," proved that it was possible so to construct vessels as to enable them to engage land batteries, with at least equal chances of success. The English Admiralty followed the example thus set them; and after numerous experiments upon the resistance offered by plate-iron to the bolts propelled by new cannon, the result was the production of the "Warrior," avowedly built in rivalry with the French ship "La Gloire," which had recently been constructed under the orders of M. Dupuy de Lôme, and which passed then for the greatest improvement in naval architecture effected by our neighbours. No doubt, there were in this essay a great many things done which would not be repeated at this day; but the great principle was admitted, that a vessel could be constructed with an iron skin, which should be capable of repelling an enemy's shot. The greatest error in the construction of the "Warrior" was, however, in the mixed nature of her hull. She was invulnerable in the centre part, but vulnerable at the bows, and at the stern; whilst her iron plates were backed with wood, which was

thought to be necessary, to deaden the blows of the cannon fired against her; and she was masted like an ordinary wooden vessel. I have myself frequently called attention to the danger that exists of placing iron in contact with wood in sea-water, because a galvanic action is set up between the wood and the iron, which causes both those materials rapidly to decay; and because there is nothing whatever to prevent the attacks of the *teredo navalis*, which take place under shelter of the plates; and for both these reasons, I should be disposed to expect that the "Warrior," like the "Gloire," would have a very limited duration. It appears that the French engineers have also found that this is a real, practical objection; and the "Normandie," a frigate launched with great *éclat*, has, after a very short service, been obliged to be repaired entirely, on account of the rotting of the timbers, and the loosening of the bolts which fasten the plates of iron that enter into the construction of her sides. There is, in fact, in all these cases, a species of oxidation set up between the wood and the bolts or fastenings, which rapidly loosens them, and gives the water access to the interior of the wood, which is then, under the conditions of moist heat, the most favourable to decay. The best method of attaching the plates to the sides of iron ships, appears to be the system lately adopted at Portsmouth, where the joints are made to butt against one another, without the intervention of any feathering or grooving, or of any tying-down bolts; but all such systems are but partial palliatives of the inconvenience. The only remedy to this evil seems to be, to construct the vessels entirely of iron, stem, centre, and stern—frame as well as lining. But there seems to be an objection to this system, in the fact that bottoms of iron ships rapidly become foul with weeds and shell-fish, thus rendering it necessary to dock the vessels often. In the English dockyards this is a very serious difficulty, for they are not large enough to admit craft of the dimensions of the "Warrior," in the majority of cases; and the "Achilles," "Northumberland," "Minotaur," "Agincourt," &c., are even larger than the "Warrior." I think also that the style of masting the English ironclads is a great mistake, and that, in an action, the "Gloire" would present a marked advantage over them, in having lighter spars and rigging. However, in the last constructed English vessels, the weight of armour—which must be placed above the centre of gravity of the floating mass—is increased by an extra thickness of an inch iron; and the present thickness, of $5\frac{1}{2}$ inches, is becoming so great, that the advisability of substituting wrought iron for the framework is forcing itself gradually upon the attention of our rulers, independently of the conditions of decay of the wooden frame.

Whilst the Admiralty were making the experiments upon the strength of ships, thus briefly adverted to, the Government of the day had entered into an arrangement with Sir William Armstrong, by which that gentleman, in fact, became for the time possessed of the patronage of the nation. His gun seemed to possess the advantages of long, steady flight; but it was not adapted to be fired at close range, and, indeed, in this respect it was inferior even to the

old 68-pounder smooth-bore gun. There would appear to have been very different opinions formed with respect to the merit of Sir William Armstrong's invention, at home and abroad; for the report by M. Penguilly L'Haridon, published in the *Moniteur* of 25th November, 1860, after paying several compliments to the inventor, on account of the ingenuity displayed in obviating some of the practical defects of the weapon, goes on to say that the pieces sent to China rapidly became useless; and he especially alluded to the fouling of the pieces by the lead with which the shot are surrounded, as entailing the necessity for frequently sponging out the portion of the cannon which produced the effect of rifling. The influence of Sir William Armstrong was nevertheless sufficient to induce the Government to adhere to his weapon, and thus little was done comparatively in the way of experiments with other guns—notwithstanding the report by Major Hay, which the public was led to believe to be unfavourable—until at length Mr. Whitworth succeeded in obtaining for his system the advantage of a public trial; and then the whole question of the kind of ordnance was re-opened. Sir William Armstrong, Messrs. Whitworth, Bashley Britten, Lynall Thomas, Commander Scott, R.N., Captain Blakely, and others, have all been admitted to compete; and the opinions of the most competent men in the service are still divided upon the respective merits of the various systems of ordnance proposed. The Cavalli guns, the French rifled cannon, the Belgian cannon, and even the Prussian and Swedish forms, have been tried, with variable success; but the balance of opinions in England seems at present to incline to Mr. Whitworth's cannon, both on the score of its penetration at a distance and of its initial velocity. The whole of this discussion, however, shows the danger of the Government giving itself up exclusively to any one manufacturer, because he must always be more or less interested in adhering to the system he himself is concerned with. And it is to be feared that the English Government has in this case been induced to spend money in the prosecution of experiments, for the sake of improving the Armstrong gun, which, if spent upon other systems, might have given results even more satisfactory than those yet obtained. It seems that Mr. Whitworth has succeeded in sending his shot and shell through six inches of solid iron, and he promises to do even more. He has effected this, also, with comparative ease; and there is not the danger to the artillerymen that has always attended the use of the Armstrong weapons, where the vent-pieces are constantly getting out of order, the shot stripping, or the shells bursting as they leave the guns. It is not my place to express an opinion with respect to the merits of the different guns; but I may be allowed to express my regret that the Government should have for so long a period given itself over to Sir William Armstrong. At any rate, as the discussion about the penetrating power of projectiles will have to be referred to in the sequel, it will be advisable to defer what may be said upon this subject for the present.

The question of the gun to be used, and of the thickness of iron to resist its effect seem, however, to be very closely allied; and the

great changes lately introduced in the art of gunnery have complicated the question, by rendering it necessary to increase the weight of the guns to such an extent as to make them too heavy for the ordinary broadside of a vessel. We hear of solid shot weighing 460 lbs. being thrown from the large guns used in the American forts; and the strength, weight, and recoil of these weapons must be proportional to that weight, which is far superior to that which the sides of a sea-going vessel can carry. In such cases, it is evident that the means of defence at the command of a belligerent upon the mainland must be greater than those of an enemy who should attack him by water, if the ordinary methods of fighting the guns of a ship be resorted to. This objection seems to have struck Captain Cowper Coles, R.N., and he has attempted to obviate it by the construction of the cupola ships, which are but the development of the rafts of the same inventor, and which has been applied by the Americans with so much temporary success in the "Monitor"—avowedly built upon the model of Captain Coles' vessel. In the story of the famous duel between the "Merrimac" and the "Monitor," in fact, much of the history of the recent discussions may be traced; and the various lessons read by Europeans have been commented upon by the belligerents in America. The "Merrimac" was really an iron-clad ship, with an immense iron rostrum, or beak, and a battery of heavy guns fired from the broadside. The "Monitor" was a cupola ship, with a tower erected above the water-line, within which two guns were placed; and the tower was moved by machinery, in the style of a turn-table, so that the whole fighting power of the vessel was confined to the cupola. Both the "Merrimac" and the "Monitor" were *rough* and *ready-made* attempts to settle the question as to the construction of this class of vessels; for the first was nothing more than an old wooden frigate which had been cased with railway bars, and the "Monitor" was plated with iron of about 1 inch in thickness upon the deck, which projected about 7 feet on each side, and 24 feet at each end, beyond the part of the vessel it was destined to protect. The tower also was built in a very temporary manner, of plates of iron 1 inch thick, superposed on one another, and it owed its powers of resistance to its shape, quite as much as it did to the iron-work of which it was composed. In the action fought on this occasion, the deficiencies of the wooden ships were made painfully apparent, by the sinking of the "Cumberland," and the striking of the "Congress" to the "Merrimac;" but when the "Monitor" appeared, the short-lived triumphs of the Confederate forces were numbered, and the two vessels, after cannonading one another for five hours, without effecting any damage to their armour-plating, withdrew from the contest. The "Merrimac" had, indeed, suffered more than her rival, for her captain was seriously wounded, and her beak was broken in her attempts to run down the "Monitor," which was protected by the projection of her side and ends, from this formidable mode of attack. The result of the encounter thus seemed to prove that the "Monitor" was the more formidable vessel of the two; but there was really little reason for the shouts of triumph with which she was hailed; and

the events which happened before and after the battle, proved that her designer had entirely lost sight of the sailing properties of the vessel, which, by the way, seem to have been as much neglected in the case of the "Merrimac." Both vessels were adapted for river work, and for the large creeks that cut up the coast of America; but they were neither of them adapted to the necessities of deep-sea navigation. The "Monitor" nearly sank in her voyage to the scene of her exploits; she went down at sea when an ordinary vessel would have survived. The "Merrimac" was blown up in harbour, because the Confederates had not confidence enough in her to send her elsewhere, when they lost the command of Norfolk Harbour. Captain Ericson's boast as to the merits of the ship, and of the intentions with which she had been constructed, may, therefore, be treated as perfect specimens of American boasting.

The naval authorities of the United States have, however, been induced to order a great many of the "Monitor" class of boats; and I must confess for my part that I think they were right in doing so, for the special purpose they had in view. I think also that the defects above noticed in the "Monitor" (of its unseaworthiness), are susceptible of being remedied; and that the class of vessel in question will become a formidable and efficient means of attack. The error in the "Monitor" was in keeping her down in the water beyond what was reasonable, so as to place all her guns and machinery below the water line, and to leave so little above that line that her powers of floatation were diminished to a perilous degree. The efforts of naval architects must be turned, then, to securing a sufficient height above the water of the decks of cupola ships, to allow of their carrying their weight of armour, and their turrets, at a distance which would insure their seaworthiness in all states of the weather. No doubt this advantage would be purchased by the corresponding disadvantage of leaving the vessel exposed to the effects of the beaks of an enemy's vessel, and would render necessary the construction of the sides in stouter metal than was employed in the "Monitor;" but there are such advantages in concentrating the power and weight of the guns into the turrets, that they must, sooner or later, be accomplished. In the meantime it may be said to be proved that for the purposes of attack or defence, in creeks or rivers, the class of vessel similar to the "Monitor" is admirably adapted to the present state of warfare—what it might have proved to have been in the hands of English, or rather of European engineers, it would be premature to say, because the merits of the Dahlgren guns used in the "Monitor" are at least equivocal. The Americans appear to trust more to the weight than to the velocity of impact of the shot, and therefore their guns are inferior to those which derive their power from both sources, such as the Whitworth, the Blakeley, Britten, and other guns lately experimented upon here. The weight of the guns the "Monitor" class of vessels would allow to be used, in consequence of their being placed vertically over the line of the keel, must, however, constitute a great recommendation for them in all cases where they are likely to co-operate with, or to act against, shore batteries, which is about the style of

service they seem likely to be engaged in, in the course of the struggle now proceeding in America at least.

The American war seems to have furnished several other lessons with respect to the construction and armament of ships, which ought not to be lost upon us. For instance, the passage of the batteries at New Orleans by Captain (now Commodore) Farragut; the defeat of the attempt to force the passage of the James River by the iron-clad vessels of the Federalists, and the achievements of the "Arkansas," in her short and glorious career, may all in their turn convey a lesson to us with respect to the fact that it is not so much the style of the ship, as it is the vigour of the defence and the power of the guns opposed to her passage, that must be considered. Had the batteries at New Orleans been as powerful and as well served as those at the James River, it is hardly possible that the Federals would have been able to force the passage of the river; and the "Arkansas," after inflicting great damage upon the wooden vessels opposed to her, was obliged to take refuge under the guns of Vicksburg, being sorely injured by the shot she had received in passing through the enemy's fleet. This vessel was shortly afterwards blown up by the Confederates themselves; and it seems, from all the accounts that have been published of her construction, that she was not quite invulnerable to the heavy guns with which the Federal fleet was armed. The whole of this American contest proves that which was already well known, that war is, after all, resolving itself into a struggle on the part of belligerents to unite the greatest possible amount of the means of attack and defence in the positions likely to provoke the attempts of an enemy. In this matter, the land defences must always have a great advantage over the attack by sea, because it must be easier to manœuvre heavy guns in the former case than in the latter, and to give greater steadiness of fire to them than can be obtained in the moving structures "which walk the waters." It is a struggle as to which nation, or which section of a nation, may possess the greatest amount of disposable mechanical ingenuity at the command of its leaders; for just as the means of offence are increased, so do the means of defence also make as rapid strides, and the contest between offence and defence remains the same, only that the cost of both operations is increased indefinitely.

Our Government is endeavouring to advance the object of making the cost of war a great drawback on its indulgence, by the experiments upon guns, and by the trials which it is making of the steam-engine in its application to the purposes of moving vessels intended for the purpose of carrying the armaments which modern ingenuity has placed at their disposal. Amongst the most important of these which have lately been made is the application of a double screw to a vessel which should allow her to turn upon her pivot, in a manner to bring respectively the guns of both her sides to bear upon an enemy. Each screw upon this system is propelled by a separate engine, and the vessel can be built perfectly flat on the floor, in the midship section, and without any keel, so that a perfect steering power is obtained without any assistance from the rudder, whether the ship is going

ahead or astern. Hitherto the experiments upon this system of the application of power have been confined to vessels of small burthen, and such as are applicable to river service only, as the "Flora" and the "Kate," for instance, neither of which was of greater burthen than about 500 tons, and had a displacement of more than 7 feet 2 inches aft, and 5 feet 4 inches forward; but there does not appear to be any reason for not applying it to much greater dimensions than those mentioned. The last accounts I have read were those attending the doings of the "Kate;" and in their case we find that the vessel made, "with one engine going ahead and the other astern, at full speed, the rudder being put hard over to starboard, two circles complete, the one in 3 minutes 44 seconds, and the other in 3 minutes 55 seconds; and when the rudder was fixed amidships, and the screws working opposite ways, the first circle was made in 7 minutes 10 seconds, and the second in 6 minutes 40 seconds." The rudder was fixed aport, and the screws still worked different ways, when the ship turned round in 4 minutes 17 seconds; and, lastly, when the rudder was fastened amidships, and both screws were going astern, it was found that she steered perfectly by altering the velocity of the screws. It seems, then, that the desideratum of obtaining a power which should allow a vessel to bring its two batteries to bear upon a land fortification, in turn, has thus been obtained; and that the defects which were so evident in the "Warrior" and the "Black Prince," of the unwieldiness of their mass, have been obviated in the "Kate," which would allow of a powerful armament being transported in rivers as tortuous and as encumbered with shoals as those of the Thames. There is, however, nothing new in this application of steam power; for many years since it was proposed upon the French canals, but the project then fell flat upon the public ear, which began at the time to be occupied by the din made by railway working. It is revived now, and may do good service to the Admiralty, thanks to Captain Symonds for his advocacy of the system of Mr. Roberts, as applied to deep-sea boats, in the course of the discussion with respect to the ships which Mr. Scott Russell contends that it owes the nation.

There are some other experiments still before the notice of the Admiralty which may materially affect the building of ships intended to carry heavy guns, amongst which may be cited the application of double or triple keels to iron-plated or to flat-bottomed boats, with a view to increasing their steadiness in the water, and to prevent their falling off so much to leeward under sail. The propulsion by jet and by disk, have also been suggested, but they do not seem to have met with much favour from practical engineers, and they may be regarded rather in the light of scientific curiosities than in that of useful applications of known principles. At any rate it is not our province as yet to pass an opinion upon the schemes of the men who propose these modifications of the means of propulsion, because they have not yet been advanced to anything like a practical result. The "Kate," in fact, seems to be the most decided success in the way of improvements in the application of steam power to sea-going vessels, and it is more than probable that an adaptation of the system of the treble keels

will be found to be advisable in the case of the vessels built upon her model. The "Kate," as has been said, is perfectly flat-bottomed, and must therefore roll much when exposed to a cross sea; her two screws are, in fact, absolutely necessary to prevent the vessel from falling off before the wind, and a great deal will depend upon the perfectly isolated character to be given to the engines.

The question of surface condensation has lately attracted a great deal of attention amongst practical engineers, who are interested in the naval service of our country, on account of the great economy it is likely to introduce in the boiler space, and in the consumption of coal it produces. There have been several experiments tried upon this subject in the course of the last year, all with satisfactory results, so far as regards the conditions of economy of working; but still it would appear that there is a great outlay, and a great complication of the machinery to produce the desired effect, that I am convinced might be avoided.

The event which lately took place in America, in which the much-talked-of "Alabama" captured and sank the "Hatteras," and the more recent destruction of the "Queen of the West," seemed to show that for deep-sea service, wooden vessels may, after all, possess very valuable qualifications, which may go far to counterbalance the supposed advantage resulting from the invulnerability of the ironsides; and our Government would do well in hesitating before it engaged itself too deeply in the construction of the latter class of vessels. The "Alabama," as is well known, is a wooden vessel, with great steaming power, and very heavy ordnance; the "Hatteras" was an iron boat, with a broadside said to have been composed of two short 32-pounders, one 30-pounder rifled Parrot gun, and one 20-pounder rifled gun. The engines of the first were all kept well below the water line, those of the latter have not been described, but they may be considered to have been of the usual American type, high above the water, and much exposed. In the action which ensued, the "Alabama" made every use of her superior steaming power, and she seems to have deliberately chosen the positions in which to deliver and to plant her shot; whilst the commander of the "Hatteras" was obliged to receive the fire of his opponent just as he chose to deliver it, on account of the small power of his vessel, and the utter unseaworthiness of her build. The consequence was that, in a short time, a shell from the "Alabama" entered amidships in the hold; a second passed through the sick bay, and exploded in an apartment adjoining; and a third effectually destroyed the steam-engine of the "Hatteras" by knocking the cylinder to pieces. The captain of the latter vessel then finding that he was unable to contend any longer with his enemy, who had placed himself athwart his bow, and was prepared to give him a raking fire, struck his colours, and very soon after the "Hatteras" went down, with all her stores and armament, so fearful had been the damage inflicted by the shot and shell of the "Alabama," which does not appear to have been seriously hurt by any of the guns brought to bear upon her. It may be said that a different armament of the "Hatteras" would have materially altered the fate of this encounter,

and that the application of the double screw, for instance, would have enabled her to have brought her guns at once into position; but I cannot help suspecting that for sailing, or deep-sea cruisers, the real course is to make the vessels as swift as possible, and to give such power to the engines as to enable them to select whom they will attack, and the time and manner of doing it. The armament used in these cases must, of course, be a very powerful one, but it is possible to unite these conditions with great steaming capacity, as was the case in the "Alabama;" and the result of the union must be to enable the vessel which possesses these qualities, to command the commercial marine of the contending power at least. As to the services of such vessels as the "Alabama" against the land defences of the enemy, they do not seem to have entered at all into the calculations of the designers of that craft, but they who know how difficult it is to hit a vessel moving with great velocity, and subject to the rolling that every sea-going vessel must encounter, will be able to appreciate that source of her diminished power. Captain Farragut's exploits with his wooden ships against the Confederate batteries at New Orleans, may, perhaps, give the best practical answer to the questions which might be raised on this point; and they certainly go to show that the efficiency of men-of-war depends, even at the present day, far more on the skill and daring of the officer in command, than upon any defensive armour that may be used, it being always understood that the construction of the vessel is such that she shall possess the means of enabling her to choose her own time of fighting.

The story of the "Queen of the West" is, in fact, the same as that of the "Hatteras." She was rendered unmanageable by means of a shot in her boiler, and thus became a prey to the Confederates. The "Monthauk" has more recently still, made an attempt to revive the confidence of the Americans in their iron-clad boats, but with very indifferent success; for she seems to have cannonaded a fort for some time without making any impression upon it, though her sea-going qualities were certainly superior to those of the "Monitor." It would appear that the Americans were, indeed, working out the problems presented to our naval authorities in a very rough manner, it is true; for they are obliged to meet the wants of the day with such means as they have at hand; and in the case of the "Monthauk," they seem to have opposed to the floating battery brought against it, an iron-plated fortification—a system which we have lately applied to the sea defences in Portsmouth Harbour. Yet the experience gained in these respects will greatly serve us, if we would only read the lesson aright, and be taught by our Transatlantic cousins the advantages and disadvantages of the various systems proposed.

A great deal of attention has been directed to the progress of the "Royal Sovereign," iron-cased, screw-steam, cupola ship, now being converted under the inspection of Captain Coles himself, who has been allowed by the Admiralty to superintend the application of his invention, so as to ensure its efficient trial. This vessel seems to be, in the first place, a repetition of the Admiralty's method of coating a wooden hull with iron, to a certain depth, at least, below the water-line; for

the plates are supported by a horizontal coating of timber, placed at about eighteen feet below the point to which the ship was cut down, thus leaving the ship quite bare, and exposed to any submarine explosive weapons below the water-line. The deck is made sloping, so that, in fact, it resembles a butcher's tray, the sides forming the glacis of the turrets, the framework of which is supported by wrought-iron beams, 4½ inches thick. The turrets are about 7 ft. 2 in. above the sides of the deck; and as there does not appear to be any reason to question the sea-going power of the vessel thus converted, we shall soon be in a position to ascertain whether the fate of the "Monitor," and the recent defeat of the "Monthauk," were inherent upon the method of construction, or on some defective working out of their details. The experiment cannot, however, be said to have been effectively tried, inasmuch as Captain Coles has not been able to construct his vessel expressly for the trial of his system; but an old vessel has been given him to convert to the purposes of a cupola ship. Still, the invention of Captain Coles professed to be applicable to existing hulls; and it must be judged in this way. We shall, at any rate, be able soon to know whether there be any practical difficulty in working 20-ton guns in the turrets, instead of a greater number of smaller guns over the sides of a vessel; and thus the whole question of the nature of the armament of our iron-clads will open itself afresh, as it has done in America. The questions of the ventilation, the lodging of the crew, and of the noise of the guns, and the smoke resulting from them, will also gain much by this experiment.

Perhaps it will not be considered amiss were I to say here a few words on a subject which has lately attracted a great deal of notice from the public, viz., the execution of works by Government employés in the docks, and by private contractors. My own sympathies are all with the latter body of men; but if there be—as no doubt there are—some contractors who would carry out their undertakings strictly and honourably, there are so many who would be disposed to take advantage of any loop-hole, that I cannot see the way to dispense with the strictest Government control and Government interference with these matters. It has been the complaint that the quality of the iron supplied has not been equal to the requirements of the service; and any one who has been acquainted with the iron trade will at once recognise the truth of this accusation, which has been felt, not only in respect of the quality of the plates, but also in the supply of chain cables, and in the common iron of commerce. It is asserted that the private contractors do not comply with the conditions of time, or those of execution, in the works they undertake; that they are, as a rule, guilty of slovenliness of work; and though, in particular instances, a good answer may be given as to the causes of the delay, and even of the slovenliness of work, it is too much in accordance with the laws of human nature that the contractors should endeavour to obtain all the profit they possibly can do from any particular work, for the Government to give itself over to their tender mercies. There must be Government establishments where the ships of war can be built, for everything about those vessels depends upon the style and manner of carrying out the details

of the work, which must be done carefully and conscientiously; and a contractor is always tempted to neglect the small precautions necessary to produce this result. I say it advisedly, and from the result of long experience of contractors, that I, for one, should be very sorry to see the building of iron or of wood ships transferred from the hands of the dockyard authorities to private builders. It is, perhaps, true that there is waste in the dockyards, that there is plunder going on in those establishments, and that many men live upon the sums thus filched from the nation. All this is an evil attending the system of a nation's doing for itself what private enterprise could do for it; for there is not the inducement to a strict supervision that private parties would introduce; but the consequences which would result from the "scamping" of the works are, in naval architecture, so serious that it is desirable to run the risk of the peculations of the parties employed in order to avoid it. The great thing to be done, is to establish a system of checks, which should maintain the honesty of the Government employés, and which should leave the Admiralty free to resort, as far as possible, to private industry, retaining under its own control the more important branches of the service. It would be a sad day for the nation, when the dockyard authorities should find their powers interfered with, or their power of action diminished, in order to give the monopoly of the construction of vessels to the great industrial houses.

Be this as it may, and to return to our immediate subject, it seems to me that the experiments at Shoeburyness, upon which the dimensions of the iron-plating to be adopted in our vessels are founded, have been made upon very different conditions from those which will actually be found to prevail in practice, and that the results they appear to lead to, will be discovered to be far in excess of the requirements of the case. The tendency of what has been observed there, is manifestly to lead to such an augmentation of the strength of the plating of vessels, that they will not be able to float at all if the progression is to be kept up; and really it would appear to be the case that we are arriving at the same conditions, with respect to defensive coating, as those military engineers of the middle ages were with respect to defensive armour. From the experiments tried, it would seem that the thickness required to resist the impact of the 68-pounder is not less than $5\frac{1}{2}$ inches, and the penetrating powers of the Whitworth $7\frac{1}{2}$-inch gun, and of the smooth-bored Armstrong 100-pounder, are much more than this; in fact, in the recent experiments as much as 12 and 13 inches of iron were tried. But the question arises whether these trials are ever likely to be made in fact. A ship is a moving object, the difficulty of hitting it being increased by the rate of speed and the inclination it may take under the influence of the sea; the precision of firing required for the heavy guns may be attained on shore, or in the defence of a fortress, but it is not likely that the rough strength of sailors will be taught to make itself conform to the minute precautions required for its attainment. The firing at Shoeburyness has too much the air of a philosophical experiment; it is not such as would occur in actual warfare, and it gives results such as would be attained if all the conditions were realised, but which they

would seldom be. There is little known yet to induce the Government to build ships with more than 4½ inches of plate; that is the thickness required to render vessels practically invulnerable, and at the same time enable them to retain their sailing powers; anything more that might be required could easily be obtained in the way suggested by the experiments of the 3rd of March, when the trial was made upon two thicknesses of iron, and an extra coating could be added to the vessels intended for the special service that would require the extra thickness. The results of the last experiments at Shoeburyness are, indeed, rather interesting to the military, than to the naval, engineer. The former must calculate upon dealing with all the resources that the talent and skill of an enemy may bring to bear against the works he constructs; the latter has to consider the means he can command in the skill of the men and the speed of his vessel; and the first of these conditions is rarely of a nature to admit of great precision in handling the guns; the last will always introduce so many disturbing elements into the calculation that it may safely be said that not one shot out of a thousand would tell. Great Britain is a country possessing a large colonial empire, and having interests to defend in every part of the globe, so that her fleets must be prepared to do battle for her supremacy in every part. This will be best effected by the construction of quick gun-boats, heavily armed, in the style of the "Alabama;" they may, according to some authorities, be partially armour-clad, but they must be entirely so, according to the results of experience, if at all; for the experience derived from that vessel goes to show that she could rake the "Warrior," or her sister ships, from fore to aft, whilst they were attempting to bring their broadsides to bear upon her. The vessels destined to be built to resist the shot lately fired at the Inglis shield, might very well be retained for the defence of our shores in aid of the detached forts; and the Coles' cupola ships, I suspect, would be found best adapted to this service also; at any rate, the former are never intended to go to sea.

The questions connected with surface condensation, and the economy of space in engines, are, after all, quite as much connected with the commercial marine as with the fighting branch of the profession; and, therefore, they may be left to be worked out by the parties connected with the former. In the course of the last few years there has not been any very great change in the details of the steam-engine applied to vessels of war, to call for our attention, excepting the application of the double screw to the "Kate," and some slight modifications in the outline of the screw itself. In the transport service, too, there has been no alteration of importance, for the "Himalaya" still retains her pre-eminence in the class of vessels devoted to this service. She was built by private contract, it is true, and has proved to be a first-rate boat from the day she entered the service of the country; but I would observe that the exception does not make the rule, and that the peculiar service this boat was destined to perform, and the style of finishing admissible in her, were perfectly in accordance with the mode of construction adopted in private building yards. There has not been any call upon the resources of our country in the

respect of the transport service during the last twelve months moreover, for the excitement about the Trent outrage had died away before the year began, and we have not had occasion to send troops to any part since that period. On that occasion, the land and sea service was found to be well adapted to the wants of the occasion, and they were well seconded by the railroad and dock authorities. So well, indeed, were the duties incumbent on all parties performed that it would be hard to suggest where improvement could be made. The use of condensed water for drinking purposes, with the application of electricity for the purpose of giving to the water a greater degree of wholesomeness and freshness, is, indeed, the only thing that I have heard of which would be likely to affect the comfort of the soldiers and sailors thus transported—to use the word in its proper, not in its secondary, sense.

In respect to the system of signals, a great improvement has of late been made in the adaptation of Way's electrical light to the night signals, whether they be meant for the purpose of directing the movements on board, or to communicate with the shore. As is known, this light is obtained by breaking the circuit of the battery at the point where a capillary stream of mercury begins to separate into drops, and its merits consist in the rapidity with which the battery can be set in action, or placed at rest; the disadvantages are the evaporization of the mercury, which is found to be very great, practically, so much so as to have hitherto prevented the application of the system. I am told that this inconvenience has been obviated of late, and the constancy of the light will, I believe, in this case, secure its adoption, not only for the signals of men of war, but also for the purpose of lighthouses. In the particular branch of the service, applicable both to the commercial and royal marines, there has been little change, beyond the introduction of gas lighting, into many of the harbour lights, which are situated upon the extension of the mains. The service of the lights and beacons upon our coast continues to be performed as well as it has always been, and any change in the system on which it is managed would but be attended with disadvantage to the country. The outcry that was raised about eighteen months ago on this subject seems to have subsided, and the Trinity House are reinstated in the position they held in public estimation. Great uncertainty appears, however, to hang over the proceedings of the Board of Trade in this respect, for in the colonies the lighthouses built have, in some cases, proved failures, and the Board has not had the courage to meet the difficulties of these cases fairly. The use of Coignet's *beton-agglomeré* would, I am convinced, obviate many of the difficulties in the way of the construction of these establishments, and allow of their being solidly and economically built. I may speak of this system hereafter, but I would say at once that it consists in slacking the lime with just the quantity of water necessary for the hydration, pugging the mixture of the material with the sand, or ballast required, and then ramming it with small punners in place. The result is a solid mass, which has all the hardness and the consistency of a monolith, of any degree of hardness that may be desired.

Finally, it appears to me that we may consider the state of applied science to military engineering as bearing upon the construction of the navy especially, as being just now in a state of great uncertainty. The recent invention of rifled guns, and the more recent introduction of iron-plated vessels, have disturbed all the arrangements, all the plans, of the designers of our navy; and the improvements which have taken place in the services referred to have been so rapid, that the vessels which would meet the requirements of the day would be found, perhaps, useless to-morrow. The attitude of the Government, in this state of affairs, clearly ought to be one of expectation; it should hold itself in readiness to adopt every improvement, but commit itself decidedly to no definite course of action, so as not to have thrown upon its hands an obsolete system. The other branches of engineering connected with naval warfare are very little affected by the great changes going on in the construction of ships; for docks, lighthouses, river improvements, and the making of harbours, are founded upon principles which are of universal application, and they have not been materially changed of late years. There may be small changes in detail with regard to them, there has been none as to the principles on which they are founded, and the whole interest connected with our present inquiry concentrates itself in the question of the construction of iron-plated ships, in popular estimation at least. This tendency is, it may be suspected, a very mistaken one; and the old theory of the Prince de Joinville, which makes the attainment of high speed and of rapidity of movement equally necessary, seems to have acquired fresh confirmation from the fact of the "Alabama's" having been enabled to sink her opponent in the manner she did. Speed is the great element of all warlike inventions, accompanied, it is true, by great powers of destruction; and the vessels which shall be found to unite these conditions will infallibly be "the masters of the position," to use a French phrase. The union of the qualities attained in the "Alabama," in Captain Coles' cupola ships, and the double screw vessels, would appear to be the most logical solutions of the problems now raised with respect to the construction of ships; the various questions connected with the permanent works for the defence of our shores, and the refuge to be afforded to our shipping, may be safely left aside, until these shall have been determined in one way or another. The present tendency is to defer the consideration of these questions; and before the great ones of the style of ship to be built, and the manner of arming it, they really do sink into insignificance, so much so as almost to justify the neglect with which the engineers of the day treat them. After all, the merits of the commander of a vessel of war will tell nearly as much with the present system of iron-clad ships as they ever did; and it is as important now, as it ever was, to maintain the traditions of the navy in all their vigour, and all their influence, upon the daring of the men employed.

LECTURE II.

Friday, April 24th, 1863.

COLONEL P. J. YORKE, F.R.S., in the Chair.

ON THE RECENT PROGRESS OF THE MILITARY SCIENCES.

BY G. R. BURNELL, Esq., C.E., F.G.S., F.S.A.

IN my last lecture I promised to return to the subject of the different systems of guns which had been presented to the Government for the military service of the country, and it seems to me that I should more appropriately do so at present, when the improvements in land fortifications are immediately under notice, than when the improvements of naval architecture were being considered. These systems all date from the time that the Emperor of the French began his experiments upon the rifled gun, and their primary interest was that which was attached to the providing a weapon which should enable the artillerymen to establish their batteries at such distances from the enemy as should be removed from the fire of the riflemen armed with the Minié and the Enfield rifle. Insensibly the object has been extended, until at length the rifled cannon have been considered as the weapons to be employed as heavy guns, and siege trains, and the whole conditions of the manufacture of those weapons have been entirely and radically changed, and with them the whole science of gunnery, as applied to operations of siege and of field service.

The operations of the French artillery in this matter were, it is well known, entirely confined to rifling the ordinary field-pieces, and the first services rendered by the rifled guns were those in China and Italy; but very shortly afterwards, the siege of Gaëta brought into evidence the advantage of the Cavalli breech-loading guns, which certainly contributed to the prompt surrender of that place, after the French force was withdrawn. Our government had entered very warmly upon the point thus opened, and Sir William Armstrong was nominated to a post under the government, with the avowed intention of developing the system he had invented, in which the rifling of the

gun was combined with the breech-loading principle, and the casing of the shot with a soft metal, so applied as to cause it to assume the rotatory flight with ease. The Armstrong guns were sent to China with results which we have seen, and the objections raised to their employment, on the score of the fouling of the pieces, seem to have been confirmed by the experiments subsequently tried here; but the size and power of the guns experimented upon had considerably increased in the meantime, and Sir William Armstrong has rendered great service to the construction of artillery by the methods he has introduced for building up the guns. It may be questioned whether there was not too much complication in the manufacture of the last weapons—the breech-loaders of Sir William—for in the field, or in siege operations, we are always obliged to trust the handling of those weapons to a class of men who are more remarkable for their bodily strength than for their intellect; and the mathematical correctness of fire, that characterises these guns, would hardly ever be attained in practice, when the men were fighting, and the hurry and excitement of the battle were upon them. The experiments of the Government upon the Armstrong gun, had, however, been carried on without much consideration as to cost, and they had gradually led to the belief that the old-fashioned smooth-bored 68-pounder was a more efficient weapon for close quarters than the new gun. We find, then, that the efforts of our artillerymen were directed to the preparation of large guns, on the system of the 68-pounders, of which the 300lb. shot of the Armstrong gun, fired at the Inglis shield, may be considered to be the type; but, in the meantime, Messrs. Whitworth, Lynall Thomas, Bashley Britten, Commander Scott, R.N., Captain Blakely, and others, had continued their efforts towards the attainment of the best system of rifling cannon; and even Sir William Armstrong himself sought to employ the rifling principle in the case of the 300-pounder gun, which was calculated to throw a 600lb. shot when rifled. The fact appears to be, that in guns with a fair charge of powder, the effect produced is in proportion to the weight of the shot, and the velocity with which it strikes the object, which is greater with the smooth-bore than with the rifled cannon for a short range, on account of the friction the shot meets with in traversing the gun; but the sustained flight of the projectiles from the latter, in my opinion, compensates for the difference observable. I have already protested against the principle upon which Sir William Armstrong was allowed to make his experiments at the expense of the country; because, in this manner, every inventor has laboured under a disadvantage in bringing his ideas to a practical bearing, which his successful rival has not encountered; but the interest attaching to the subject has been sufficient to induce many of those inventors to persevere in their attempts, and finally to lead to the belief, in my mind, that the course adopted in this matter was a mistaken and a false one, viz., the adoption of the smooth bore, as in the case of the Whitworth rifled gun, the effect produced, on September 19th last, was sufficient to cause a great revulsion in favour of the rifling principle, and of muzzle loading.

It appears that at present the experience gained by the recent

experiments on guns has resulted in this: that the Whitworth guns, in the year 1862, were enabled to send a flat-fronted shell through a 4½-inch plate, and to burst the shell on the inside of the wood-planking and the inch iron skin; there have yet been no direct experiments upon the 5½-inch plates backed in the same way, so that the ultimate resistance of the iron cannot be said to be known, though from the resistance offered by the timber backing of the Warrior target, there can be little doubt but that the Whitworth gun would traverse the 5½-inch plates easily. The Mersey Steel Company's gun, at the distance of 200 yards, with a charge of powder of 75lbs., sent a shot weighing 270lbs. through 4½ inches of iron backed by 18 inches of teak; and it was the opinion of many persons who assisted at the experiments that this gun would have produced the same effects at 800 or 1000 yards distance. The more recent experiments upon the Inglis target seem to show that two thicknesses of plate-iron of about 6 inches each would be required to resist the effect of the modern artillery; and it is equally certain that, in future, all the works that are destined to resist the fire of the heaviest artillery, must be clothed in armour of this description, if they be intended to resist the direct impact of the shot now brought to bear against them. Mr. Lynall Thomas has succeeded in making a gun which has produced the same results as those recorded of the Whitworth rifled cannons; but the important part of the matter is; that no description of plating can resist the effect of either breech-loading, or muzzle-loading, rifled, or of smooth-bored guns, unless it be executed in two layers of about 5½ or 7 inches of iron placed cross-wise, or at right angles to the joints, one of another. It appears to me, that of the shots tried, the flat-fronted steel shell of Mr. Whitworth would have the greater penetrating power, for when it becomes a question of penetrating iron, the quality of the metal used must be a very important consideration; but the attention of artillerists has been so exclusively turned to the power of the gun to carry a certain weight of shot, that they have neglected to consider the nature of the material to be used in its composition. We must expect shortly to hear of experiments being tried upon the application of Bessemer's steel to the guns, and to the shot they propel, especially if the effect of the shot shown upon the metal can be eliminated, and doubtless then there will be great changes introduced in the implements of war, which will allow of their being made much more lightly than was the case with the Mersey Company's gun, or even than the Whitworth muzzle-loader. As it is, the tendency of all the experiments is to increase, day by day, the power of guns to penetrate iron, and thus to render necessary the employment either of greater thicknesses of iron plates upon fortifications, or the employment of some material which should possess greater powers of resistance to the projectiles used. It has been proposed, for instance, to coat the fortifications of Portsmouth harbour with plates of iron 5 inches thick; but evidently this thickness would be insufficient to resist the effect of the Whitworth shells, if it were executed in ordinary iron, and the action of the "Monthauk" of America proves that this contingency is within the bounds of possibility. So that the

progress of guns only leads to a corresponding advance in the art of defence against them, and both of these tendencies display themselves in the increase of the cost of the art of war, which, it is to be hoped, will soon become so great as to render the recourse to it less frequent than it has hitherto been.

The French and Spanish engineers have recently experimented upon the different kinds of cannon which have been adopted in our country, and they have ultimately abandoned all idea of employing any description of breech-loading weapon, for the present at least. They regard these cannons as philosophical toys, ridiculously heavy and unfit for the purpose of actual warfare, or, at any rate, as being ill-adapted for the purposes for which field or marine artillery is intended; for which purpose they contend that the feathered ogivo-cylindrical balls that are propelled by the rifled cannon loaded from the muzzle are all that is required. The Belgian, Swedish, Prussian, and Austrian artillerists are still hesitating about the style of cannon to be adopted in their army, but hitherto they have not succeeded in introducing anything by which the inconvenience attending the Armstrong gun—namely, the danger of the shot's stripping, the blowing out of the vent-pieces, &c.—is obviated. The American gunners seem to cling to Paixhan's system in their Dahlgrens, and, generally, they prefer to make their shot strike their objects slowly, the shot being of immense weight, and impelled with small charges of powder. It may be thus that the innocuousness of the fire of the "Monitor" and the "Merrimac" may be explained, for it would be absurd to suppose that two English iron-clads could have fired at one another for five hours, without effecting greater mischief than these vessels did. The French have also, it may be added, experimented upon cannons formed of aluminium-bronze, with some appearance of success, but the cost of the alloy of this metal will, for some time, exclude it from the ordinary purposes of war.

The importance of the penetrating powers of guns is to be judged by the course adopted in the revetments of the land fortifications which are designed to resist them, and in the style of forts built for that purpose. The French engineers, in the construction of the defences of Cherbourg and Havre, adopted a system of masonry in granite, and the Russians, at Sebastopol and Cronstadt, followed the same course, with very tolerable success on the sea batteries, at least, which were bombarded for a long time by the heaviest pieces of artillery known at the period of the Crimean war. The Belgians and Dutch have continued the use of bricks, placed *header-wise*, for their revetments; and they have not, as a general rule, executed many earthworks around the most important points of their country. The Germans have long preferred earthworks, and they have executed some most important fortifications in this style; but it is in England that the attempt to use iron for the revetments of the forts to be erected for the defence of Portsmouth harbour has been made, and the experiment will be watched with considerable interest by the public, on account of the great strength and the rapid deterioration of that material under ordinary circumstances, and especially so when it is employed in sea-

water. It is true that there are some preparations for coating the iron, that are likely to arrest the progress of the chemical action in question; but anything like a coating must always be objectionable, because it is impossible to say whether it has been applied equally in all parts, and whether the lower surfaces were equally fitted to receive it. Between wind and water, then, it strikes me that the Spithead forts will be very soon decayed as though they had no revetment, and the strength of the fronts will entirely depend upon the masonry used for the backing. It may be advisable here to mention that the French engineers have lately made great use of Coignet's *bétons agglomérés* in the works they have constructed, and the monolithic character it is capable of producing is a great recommendation for that material. This *béton* is obtained, as I stated in my last lecture, by slacking the lime with a small quantity of water, that which is in fact sufficient to produce the hydration (about 20 or 25 per cent.), pugging the lime and sand with a further small quantity of water, or about 10 per cent., and then ramming the materials thus obtained, mixed with cuttings of iron wire, into moulds, which may be of any size and any shape. The results all of you might have seen, in the French court of the Exhibition of last year, and they certainly were very remarkable; so much so, that I believe myself that they open quite a new light upon the science of building, because they furnish us with the means of obtaining artificially, stone work of any size out of one solid piece; and this, too, with very small additional expense upon the price of common concrete. The advantage of thus preparing casemates, bomb proof buildings, passages, and tunnels must be apparent to all who know the importance of those works; and the *béton aggloméré* also possesses the property of resisting the action of damp upon the iron that may be used in it.

There appears to be some reason for believing that the Bessemer steel might be very well employed in these revetments, and in works of temporary fortification upon the exposed surfaces at least, just as in a smith's anvil the face is made of greater resisting powers by a coating of steel. I am not aware whether any experiments have been tried upon the powers of resistance of the material in question to the action of salt water; but I cannot see, *à priori*, that this source of danger is more to be feared than in the case of common iron. At any rate, the tendency of the present day being to substitute iron for wood, in the works of temporary fortification, it must be desirable to employ the metal which would give the greatest possible resistance, with the least possible amount of material; and these conditions seem to be united in the form of steel just mentioned. The works of temporary fortification thus referred to are the palisades, chevaux-de-frises, abattis, hedgehogs, sometimes even rifle pits, &c., and to the Maximilian towers of polygonal fortification, to all of which wrought iron has been lately applied with considerable success by the Belgian and German engineers; and the construction of shields for casemates may likewise be cited. The Belgian engineers have even proposed the use of iron rails, in the shape of the double T, for the revetments of permanent works, in combination with earth; and there seems to be every

reason for believing that the result of their operations may be satisfactory, provided a proper thickness of metal be employed. Of course there is not the same danger of the deterioration of the metal in the cases for which the iron is proposed by the Belgians, that we have seen to exist in the case of the fortifications of Portsmouth, where the action of the sea-water would take effect upon all the parts exposed to it, whereas in land fortifications the oxidation would be less general. The advantage of the railway bars is supposed to be in the greater elasticity which they contain over the continuous line of the iron plates; this may apply in the case of land fortifications, but it strikes me that a good fire towards the top of the revetment would soon detach so many of the bars as to ruin the defence it could offer.

These are, after all, questions of detail, and the great fact that we have to deal with, is the necessity for iron revetments, and for large guns which should be able to crush the fire of an enemy. The gun lately made by Mr. Lynall Thomas, was not less than 21 tons weight, and it had wheels to the carriage of 11 feet diameter. The Armstrong and the Whitworth guns lately tried were lighter than this; but even the Armstrong 300-pounder weighed 12 tons, and the last 600-pounder weighed positively 24 tons. The construction of the platforms to carry such artillery, is then a work calling for great consideration, and the foundations of the forts erected at sea, or on the alluvial mud of the embouchure of the Thames, must give serious grounds for anxiety on the part of the engineers. The latter works have indeed once yielded, under their own weight; and it is to be regretted that the tubular system of foundations was not employed for them. This system consists in sinking tubes of iron, from the interior of which the water is driven by the compression of the air, and the earth is then removed from the interior, and its place filled when the foundation has been carried down to the requisite depth, by solid brickwork or by concrete; and it seems as though it had been designed especially for this particular case. In the instance of the Antwerp fortifications, no difficulty of the kind thus alluded to has occurred; but we may be sure of this, that if it had, the engineers would have resorted to it, for the foreign engineers keep themselves more "up" to the state of the building sciences than the English do, if we may form an opinion from what occurred in this case, and in that of the blowing up of the floor of one of our docks, from the hydrostatic pressure exercised upon its bottom. It may be as well here to call attention in passing to the publication of a "Traité descriptif et Raisonné des Constructions Hydrauliques," by M. Roffiaen, Captain of the Belgian Engineers, lately issued by Tannera, the military publisher of Paris, in which the various problems connected with the application of the science of hydraulics to military works are considered with a high degree of philosophical exactitude. It is a treatise of very considerable merit, and it may be advantageously consulted by those who may have to deal with the questions of water supply, and of inundating the neighbourhood of a fortification; a system of defence far too much neglected, it may be observed, by the English engineers, though the circumstances of many of the fortifications on the low lands seem to point it out to our notice.

There is a second part of the same treatise also published, which relates to the construction of works in the sea, and in running waters, and in which the conditions of the foundations of locks, graving docks, &c., are discussed at length, with reference to the consideration of many hitherto unascertained circumstances in their construction, in the same philosophical spirit that I have already noticed with regard to the other branches of hydraulics.

The attention of engineers must, however, be called to this question of foundations, especially in these days of heavy guns; when, not only are Sir W. Armstrong, Messrs. Whitworth, Lynall Thomas, and the Mersey Steel Company running a race as to which shall be able to throw the greatest mass of metal, but even the Americans have entered on the same course with their Dahlgren and their Parrot guns. There must be, moreover, a necessity for providing against the recoil of the gun caused by the rifled projectiles, which, of course, exercise a portion of the force developed by the gunpowder exploded in them, upon the cannon itself; and this absorption of force must be always *pro tanto*, an objection to the use of rifled ordnance at close quarters. In fact, it is this condition that seems to give the preference to the smooth-bored cannon at short ranges, and to ensure the use of the rifled cannon for ships that would be able to choose their own points of attack; and it is for this reason that I think the experiments of the Iron Plate Commission might be rendered of greater value if they were made to take a wider range, so as to ascertain within what distance the projectiles discharged by the Armstrong and Whitworth guns would retain their power. It is notorious that the flight of the shot of these guns is retained at nearly the initial velocity for a considerable distance, say for 1,000, or almost 2,000 yards; and it would be desirable to ascertain whether the penetrating power suffers any diminution, in respect of distances. The choice of the weapon to be eventually adopted for the fortifications on our coasts, will be decided on some such considerations as these; and they seem to militate very much against the system of rifling introduced by Mr. Lynall Thomas, which has, moreover, the inconvenience of giving rise to a great reaction of the powder upon the gun itself, which, I think, must sooner or later, tend to destroy it, even if the system of rifling be not in itself a vital objection to the weapon.

The nature of the reaction developed by rifling seems to have been neglected by the parties who have contended for the supply of small arms for the army, and who have lately been advocating a sharp turn in the length of the barrel, to the exclusion of the mode of rifling used by the makers of the Enfield. It seems that the same description of mistake has been made with the trials of these instruments of war, that has been made with the great guns; and that they have been tried under circumstances which are never likely to occur in practice. They have been tested from rests, and the preference has been awarded to the musket that would make the best firing in that manner, instead of being awarded to the one which would make the best execution in the hands of a common soldier, who is never fitted by education, or habit, for dealing with weapons of precision. There can be no doubt

of the advantages presented by the Whitworth rifles, for instance, for firing at a mark in a rifle contest; but it seems to me a very different thing to excel in such friendly encounters, and to maintain a position taken up before an enemy. The latter is, however, the condition to be aimed at in all the weapons that are to be put into the hands of the common soldier; and upon this score, I think that the reaction which must accompany the Whitworth rifles, will be found to be a serious objection to them. The latter are well adapted, no doubt, for the service of sharpshooters, who fire from picked positions, deliberately, and in safety. The only thing required for soldiers of the line is, that they should possess a weapon which they can depend upon carrying a ball straight to the mark, within the distance at which troops are generally engaged. It is curious, too, that in the late encounters in Italy, the victory was decided by the use of what the French call *the white arms;* as though the soldiers despised their muskets, and were anxious to employ their physical force to determine the fate of the contest. Be this as it may, the result of the experiment tried at Woolwich, from the 26th February to 4th March, 1862, was very much in favour of Mr. Whitworth's small bore rifles, which only presented a mean radial deflection of ·53 of an inch in 3 fires at 500 yards range, and 2·35 inches at 1000 yards.

A very interesting question has been raised with respect to the powder to be used for the various arms, as to whether it would not be better to have it all manufactured at the Government Mills, at Waltham, or whether it should be obtained, as at present, from private manufacturers. Entertaining the opinions I do with respect to the general execution of contractors' works, I, of course, should be disposed to recommend the supply of powder being derived from Waltham; but there seems to be another reason for thus resorting to a single establishment for the supply, in the necessity for as great a degree of uniformity as possible, in the manufacture of the article. It would, of course, be in the power of an enemy to seize the establishment, if he lands in great force; but this is a contingency that is hardly worth while taking into account; and should it occur, no doubt our troops would be enabled to supply the deficiency in some way or other. There are, however, some problems about the manufacture of powder for great guns which require careful experiments, and they would be better conducted at the national establishments, even if it were decided to derive the supply of our service artillery from private makers; for instance, the Americans employ large grained powder in cakes, compressed, and with holes bored in certain positions; other people use the large grained powder without being thus compressed; and there are at present upon record no experiments to show whether there be any preference due to the system introduced by the American artillery officers. Mr. Abel has, it is true, made some very valuable experiments on the power of electricity to explode mines; but what is wanting, is a set of experiments, to show the manner in which the greatest power is exercised upon a shot by the powder burnt behind it, and the means by which the complete explosion of the powder is produced. The importance of the latter consideration cannot be over estimated in

case of rapid firing from heavy guns, such as those before mentioned; for there must be always a certain amount of risk of parts of the charge remaining unconsumed at the bottom of the gun, after its discharge, which might entail the most serious consequences to the men employed. The weight of the powder now used, indeed, seems to be the only condition which will limit the size of guns; and every thing that will tend to diminish that weight, by producing a more perfect combustion of all the particles of the powder, must become of importance. It were worth while, also, to institute comparisons between gun cotton, and other explosive compounds, whilst these experiments were in course of being made; for it is strange that this invention should have been so entirely lost sight of during late years. The Austrian engineers are said to have lately tried some experiments on gun cotton; but I have not been able to procure any report of the results so obtained.

There has been little done in the way of the application of iron to engineering structures, of a general nature, of late years, though the arts have been changed entirely in their external expression by the general introduction of that metal. The various military bridges, such as those on the approaches to fortifications, draw-bridges, and the like, are now made almost entirely of iron; but there has been no sensible change in the principles on which they are designed, either in the framework of the bridges, or in the arrangement of the chains and counterweights. In the bridge, at Kehl, there have been executed some works for the purpose of isolating the communication in case of war, which have required the introduction of large turning bridges of very considerable span, and of peculiar construction; and the huge turning bridge, lately executed at Brest, may be referred to as an illustration of the recent employment of iron in such structures, though it must be confessed that this bridge is about as inelegant a structure as can well be imagined. The Belgians, in respect to this use of iron for military purposes, appear to be the first nation in Europe, and we may mention a "Mémoire sur les Ponts Metallique," by Captain Roffiaen, as containing a brief essay upon its advantages. The full merits of this material cannot, however, be known until our army shall be obliged to establish some communications in countries where it can be easily obtained. At present the use of it is almost exclusively confined to the practice of civil engineers, to whom the construction of bridges is, by common consent, abandoned. It is not enough that in works of this description the strict requirements of science should be alone attended to; we require something more than this—an effort to unite elegance with strength must be made; and I cannot help thinking that the nation would gain vastly were the study of the arts of design made an essential part of the education of the military, and of the civil, engineer. At any rate, it must be confessed, that we, in England, have lately erected works which will not stand a comparison with the German or French bridges. I allude especially to the bridge at Cologne, Dirschau, over the Moselle, over the Rhine at Strasburg; the bridges over the Theiss, the Rhône at Tanasconne, the Garonne at Bordeaux; or those over the Loire at Mount Louis, the Soane and Rhône at

Lyons, the Seine, in its passage through Paris; in all of which cast and wrought iron and stone have been admirably employed with the best possible effect.

The employment of civil engineers, in works that in other countries are almost exclusively reserved for military engineers, appears to have taken place to a great extent in England of late years, in the construction of the works required for the docks and harbours of our coast. I think this tendency of our Government is an erroneous one, and that the great alterations that are now taking place in the science of gunnery will render it more and more necessary to "specialize" the studies that are required for the execution of those works. The size of ships, too, that are now being built must require a more intimate acquaintance with the laws of construction than would formerly have been considered necessary; and this fact alone would seem to call for the establishment of a body of engineers specially educated for the purpose of superintending the hydraulic works of the country. The fact appears to me to be that we require a special body of engineers who should devote themselves to the study of the various phenomena connected with the action of the sea, and the class of works intended to resist its effects. The importance of preserving our military posts upon the shore is far too great to allow of their being handed over to the experimental measures of engineers, who may be admirably qualified to make a railway, and yet know very little of the laws which regulate the tides and currents of our coast.

The necessity for establishing a separate department charged with the study of these questions seems to have been demonstrated by the recent occurrences on the Mississippi, at Vicksburg. In this case the American engineers thought that the town might be driven to a surrender by turning the course of the river in a fresh direction; yet the steps adopted for this purpose were so bad that even the scouring power of the running water was not able to deepen the course of the new channel cut in the course of last spring; and in this season the only effect produced by the works of the engineers has been to lay some 6,000,000 acres under water, without affecting, in any serious manner, the position of Vicksburg. The fact appears to be that the American engineers have, in this case, overlooked the natural causes which compelled the river to flow in its actual bed; and, until they be dealt with, it is impossible permanently to alter the course of the Mississippi. This is the more strange because Mr. Ellet and Sir C. Lyall have both studied the flow of the Mississippi, and it seems extraordinary that the proceedings of the Northern engineers should have been marked by such utter ignorance of the natural conditions they had to deal with. The knowledge of the water powers of a country are, in fact, an essential part of the conditions of offence and defence at the command of the officers entrusted with that duty; and the study of them must always constitute an important branch of their education, so long as the principal lines of communication are traced by the watercourses of the country, as appears to be the case in the great States of the Far West.

In the construction of barracks there may be more reason for

occasionally calling in the services of the architect than in the cases lately cited with respect to the civil engineer, especially when the barracks under consideration are to be built in London, or any other great city, where the monumental character of the buildings is a matter of importance. I do not know positively whether any architect was employed to assist in designing the barracks lately erected at Chelsea; but they are very creditable productions, and would have done honour to any one concerned, be they architect or no, so well do the accommodations provided for the officers and men appear to have been studied, so well do the necessaries of barrack-life appear to have been cared for. The same thing can hardly be said for the barracks erected at Dover lately; for they are built in such a position as to be easily shelled by an enemy lying in the Roads, and they would have to be abandoned directly an attack were made upon the town from the sea. It may not be worth while to place the lodgings of our soldiers in such positions as to ensure them immunity from the attacks of enemies approaching from every side; but in the case of Dover it strikes me that it would be more than usually necessary to secure the position to be occupied by the garrison of this place from insult. At Portsmouth, Plymouth, Milford Haven, and the other fortified towns on our coast, the works lately executed for the accommodation of the soldiers have not been very remarkable, and the old errors in designing the class of buildings referred to, have been retained. It were desirable that a better acquaintance with the laws of Hygiène prevailed amongst those who have the responsibility of this class of construction; for, at the present day, the class of buildings especially devoted to lodging that expensive creature, the British soldier, is very deficient, and it is to be feared that the mortality in our army is thus very considerably increased. The military hospitals, at Woolwich and Netley, have, indeed, been recently constructed upon recognised principles—the former entirely so, the latter partially, and only so far in opposition to the opinions of the parties who are assumed to be authorities in these matters, as may regard the position of the latter hospital. We should be very glad were there any official examination made into the alleged insalubrity of the site of the Netley hospital, and into the propriety of the arrangements of Woolwich; such an examination might furnish grounds for retaining, or for altering, many arrangements which now prevail unchanged, in the class of buildings thus referred to, and also with respect to many of the arrangements of barrack life, which seem at present to contain the germ of many diseases of a peculiar character. The experience lately gained by our officers, in the construction of the Aldershot camp, might throw great light upon this subject, obscure as it is; for the troops that have been stationed in this camp have been exposed to all weathers, and at all seasons of the year; and the situation must, therefore, have given rise to many important observations with respect to the health of soldiers encamped before an enemy, which might be of extreme utility. The experience of the French might be advantageously consulted, and many useful lessons might be learnt from the principles adopted in the construction of the barracks du Prince Eugène et de l'Empereur Napoleon, lately erected

upon the Place de l'Hotel de Ville, which are, it is true, rather too much like fortifications built for the purpose of overawing the population, than mere barracks; but which are very skilfully designed, and very well executed. The principles of the construction in this case are called for by the necessities of the position; and though we may be so happy as not to have occasion to resort to their employment, we must always calculate on their probable necessity, and provide accordingly for their introduction in the buildings intended to isolate the soldiers from contact with the mob. One essential difference prevails between the English and foreign barracks, in the greater cleanliness observable in the former; and the designers of these structures would do well to encourage the display even of this virtue—for virtue it is—and cleanliness is next to godliness, indeed, and in sober earnestness. The habits of our soldiers are in general very different to those of the civilians of even their own ranks of life; and it should be the desire of the parties entrusted with the construction of the barracks to develope those of them which are calculated to raise the tone of the body. It must be done carefully, and without the appearance of dictation; but if so done, the result will be the comfort and the well-being of the officers, as well as of the men thus assembled together. The works executed for the hospital at Malta may be referred to as models of that class of construction it may be added, though somewhat out of date for this lecture.

Whilst upon this subject, it may be as well to notice the efforts that are being made abroad to introduce some alleviation of the horrors of war by the efforts of Dr. Dunant, the author of *Un souvenir de Solferino*. The descriptions given by this author of the sufferings of the unfortunate soldiers who were wounded in that fearful contest are, indeed, heart-rending; and they form a sad contrast to the "pomp and circumstance that makes ambition virtue." It seems that in these cases the measures of the War Department are always behind the necessities of the times, and that there is a pressing necessity for good nurses, who should know how to attend those who are wounded. The object of the author of the pamphlet in question is to provoke the formation of some voluntary organization, with reference to the establishment of a body of such nurses—an object which was already partially effected by Miss Nightingale amongst ourselves, but which seems, alas! to be neglected, now the pressing necessity for the service has disappeared. By the publication of such *souvenirs* the attention of the public is prevented from becoming quite turned away from the subject, and, therefore, they do good; but it is a sad tale they tell, and one which sorely diminishes our respect for those who provoke war. The author speaks very favourably of the *sac brancard* as a means of relieving the sufferers in the field from the consequences of the jolting they are exposed to in their removal, now effected by *cacholets* or litters; but these are only palliatives, and with all the relief they offer, war still appears, as Hazlitt described it, "a sensible and thriving game only for cannibals." The very improvements in cannons and small arms we have called attention to, only serve to render the wounds now received in battle more fearful; for the contusions occasioned by the conical balls

produce injuries that are fatal in the majority of cases, and the cannon now send their shot with unerring aim. War thus becomes more horrible with every invention that is introduced; and the only hope in this matter must be, as was said before, that it will become so costly that few will be able to indulge in it. It seems advisable to add, that the experience of the French army surgeons seems to have been decidedly unfavourable to the use of chloroform in operation cases; not only because the patient did not then rally so quickly as when the constitution was called upon to make a vigourous effort, but also on account of the difficulty of producing the state of insensibility in men who were often great drinkers of spirits. The same law would, I should think, hold good in our army; and the instructions sent round to the surgeons in the Crimea are thus justified by "the stern logic of facts"—a lesson to the newspaper critics, who were so indignant at the heartlessness of the instructions referred to.

There has been a great deal of attention called to the fact of the French engineers having of late executed a series of wells in the Desert of Sahara, by means of which they have created a line of military posts in that inhospitable region; and the circumstances of the camps lately formed by our Government might seem to warrant the resort to the same system of Artesian wells. But it is to be borne in mind that the success of an Artesian well is always a problem in certain positions, until the experiment has been tried; and that, under any circumstances, it requires a peculiar combination of causes to ensure anything like an Artesian flow. At Shornecliffe, Colchester, and Aldershot, the various causes are all wanting; but they may be present in other positions, and, therefore, the results of the French experiment must be regarded with interest. Up to the end of 1860 they had sunk 50 wells, which brought to the surface 8,088 gallons per minute, at a cost of 12,000*l.*; an insignificant sum when compared with the effects that volume of water must produce in the peculiar climate of Northern Africa. The quality of the water is not everything that could be desired, but it is good enough to support the vegetation, and to content the inhabitants of these regions who have not been accustomed to anything better. The continuance of the supply also seems to me rather doubtful, especially if the water bearing stratum be so often tapped, for the accumulated resources must be affected, and the natural outflows of the springs must be also diminished. There are, however, numerous cases in which the system of Artesian wells must be applicable in the countless number of stations that fall under the control of the Ordnance Department; and, therefore, it is that the example of the French engineers is recalled. One great advantage has been found to be derived from the execution of these wells, in the settlement of the nomadic tribes of the Desert, and in the feelings of gratitude with which they regard the French Government, which has been so instrumental in the change in their habits. It is thus that civilisation is excused for its aggressive tendency; and the diffusion of the inventions and of the science of the superior race, becomes a source of compensation to the inferior for the loss of their individual liberty.

The employment of Military Engineers in the cadastral survey must be excepted from the objection which I feel to their being employed in works on which Civil Engineers should be employed; for it must always be an object for a Government to possess correct maps of its territory, for the purposes of taxation and of defence; and there can be no person so able to perform the work as the staff of the Engineers. The inch scale survey of the English counties is, in fact, a perfect model of its kind; and it seems to be all that is really wanting, for property changes hands so frequently, that the six-inch scale maps soon cease to be practically useful for the purposes these maps are designed to fulfil, and the 25-inch scale is perfectly useless. The other kinds of publications that issue from the Ordnance Survey Office, at Southampton, are extremely interesting, and very valuable. They may admit of objection from the political economist; but they certainly would never be undertaken at the cost of private industry. Great opportunities are thus afforded to the student of history to consult old and precious documents, which are reproduced in fac-simile—thanks to the efforts of Sir H. James.

A certain amount of attention has been lately paid by the officers of the Royal Engineers to the details of the service of the pontoon corps; but the improvements in this respect have been very slight—so much so as hardly to merit the patents that have been taken out for them. The transport service, or the army train, has been also lately very much affected by the introduction of the traction-engines, which seem destined to change the conditions of this branch of the service altogether; for, if we may believe the accounts we read, such an engine has lately transported a heavy load up an incline of 1 in 12, or even 1 in 8. This is a degree of inclination that even horses cannot usefully mount; and if a machine can do it, there seems no reason why its use should be confined to the mere transporting of military stores. The invention of the traction engine, in fact, appears to be likely to alter the whole practice of locomotion, and to revive the importance of the old system of road travelling. The Ordnance Office deserve credit for having constantly encouraged the inventors of this kind of engine, for they have constantly directed attention to this mode of transport, which will hereafter exercise an important influence upon the movements of armies in the field—as all who may recollect the operations before Sebastopol must be aware, where our army suffered unheard-of privations from the want of some such invention. Its influence upon the operations of our troops in India seems also likely to be attended with important benefit; for it must be evident that for many years to come the army moving in such places as the uninhabited parts of that continent, cannot enjoy the advantages of railway transport, great as those advantages are known to be in facilitating the movement of troops, and the arrival of stores. The traction engines, however, cannot do more than offer a palliative for the absence of the more perfect systems of locomotion, which must always retain their superiority over the *rough and ready* style of travelling thus mentioned; and the military engineers would do well to study the means of rendering them available in the cases where

they exist. The experience of our own army before Sebastopol, and that of the French army in the recent Italian campaigns, together with that of the American armies in their sad warfare, must be sufficient to justify the study of the means by which a railway system can be made and maintained, in actual service; and, we should think, would render it necessary in future, for the complete education of the military engineer, to study the mode of using them to the greatest advantage. The successful manner in which the troops were sent to Canada, in the course of the winter of 1862, may be referred to, as an admirable illustration of the manner in which the railways might be made to contribute to the defence of a country; and the conditions that were then found to be necessary for the orderly transport of the men and munitions, would form the subject of a very interesting memoir, because they included the conditions necessary for the embarkation of the men arrived at the end of their first land journey, and for their disembarkation, and subsequent progress, in Canada. The effect of railway communication in facilitating the operations of an army in the field must, however, be studied in the history of the Italian campaign, where the soldiers who fought the battle of Magenta were actually brought into the field by the trains; and much of the French success in that battle is to be attributed to this cause.

There do not appear to have been any important discoveries made with respect to the application of the electrical telegraph in the course of the last year; and all the changes of that science must be considered to be comprised within the duties of the civil engineer. They consist, in fact, simply of improvements in the signals, and in the means of transmitting them, which affect the whole service of the telegraph.

Finally, it must be said that the art of war has derived of late very great advantage from the improvement of the physical sciences as applied to it; and the merit of the applications in question is to be attributed as much to the military branch of the profession, as to the more exclusively civil branch. We live in an age of great excitement, when men's minds are thrown, as it were, out of their usual track; and the civil and military engineer are brought into direct competition—in the sciences of gunnery, of iron-plated ships, of the construction of land defences, and of the means of obtaining access to them. It is satisfactory to find that the Service can hold its own, in spite of the fact of the intellect of the age being turned towards these subjects; and that the military engineers still retain the high character that they always have held. With all the natural prejudices that I must be supposed to have, in favour of the civil branch of my profession, I cannot help acknowledging that we are at times much indebted to the investigations carried out by the military engineers; and though I think that there is at present a confusion of attributions prevalent among the followers of the two pursuits, still there has been so much gained by the union of the studies respectively connected with them, that I can only wish that it may continue, and repeat the old saying, *Esto perpetua*. There is something like an appearance of too much ingenuity in the pursuits of the civil engineer,

which leads them, at times, to display rather more of the pedantry of science than is required in the arts of war; but the military engineers may safely be left to repress any tendency of this description, and to reduce the theories of the amateurs to some useful result. The results of the Iron Plate Commission, as well as those of the Defence Commission, may be referred to as illustrations of the spirit that is afloat amongst our rulers. So long as affairs connected with the defence of the country shall be conducted on the principles thus exhibited, we may be satisfied with the assurance that England only arms to secure her own peace, and that *Defence, not offence*, will be her motto. It may be hard for foreign nations to believe the truth of this; for interested politicians will always be disposed to warp everything to the object which it suits their own purposes to suggest; and the bulk of mankind are disposed to add faith to the proverb, *Piensa mal, y no errarás*. But truth will prevail at last, and England will then assume the rank which she ought to do, as a great and noble nation, which only seeks for power on the condition of being able to employ it for the benefit of those who are under her dominion. The foreign critics, in the matters immediately under our notice, seem very anxious to throw doubts upon the claims of the inventors here to the originality of their schemes, and they seek to show that the germs of every good thing arose amongst their own particular nation; but there is room enough for all nations in the exercise of ingenuity in these matters, even if the claims to the merit of discovery be waived. England has always been slow to strike out new paths in the application of science; but when once she has entered upon those paths, her rate of progress has invariably been surprising. So it will be now in the application of rifled ordnance, of iron, of chemistry, and electricity, to the means of attack and defence; and though the first steps we may take, may be marked by a degree of hesitation, and we may make some blunders in our course, we may feel assured that we are at length fully engaged in measures which will eventually revolutionize the whole science of war.

LECTURE.

Friday, May 15th, 1863.

Colonel P. J. Yorke, F.R.S., in the Chair.

MILITARY SURVEYING.

By Major F. R. Taylor, Professor of Military Surveying, Royal Military College, Sandhurst.

Without the knowledge of the topography of a country, military operations in time of war could not be carried on with any chance of success. History affords us many examples of the immense advantages which have ever attended a knowledge of the ground at the seat of war, and the defeats and disasters which ignorance of it has entailed on armies; it is therefore absolutely necessary, previous to the application of strategy in determining military movements, to procure the best plans of the country that are in existence, verifying them on the ground, if possible, by actual observation, and in the absence of such plans, sketches must be made by skilled officers employed for that service; and as this duty has generally to be performed in the presence of an enemy, and sometimes under fire, the more rapidly it can be done consistent with tolerable correctness, the better. This is called field-sketching, and is distinguished from a regular military survey by the latter being usually of much greater extent of country, away from the vicinity of an enemy, the base accurately measured two or three times over, with a chain, rods, or compensation bars, according to the magnitude and importance of the survey; the angles taken with a theodolite, and the sides of the triangles computed by trigonometry.

Military surveying or topography is an art which was little known or cultivated before the time of Frederick the Great of Prussia, though Anaximander, a Milesian philosopher (who died 517 B.C.) is said to have made the first geographical maps; and doubtless even anterior to that period, the generals of antiquity had used rough sketches of the ground they marched through or fought on; for in Layard's Nineveh

and Babylon, we read of a number of bas-reliefs being discovered in the ruins, representing the progress of an Assyrian army during a campaign; I have copied one, which may be regarded as a specimen of ancient topography. The subject is King Sennacherib crossing, or apparently marching down a stream in a valley, and it is interesting to observe that some of the conventional signs which I presume were employed at that period (about 713 B.C.) are nearly the same as we use at the present day; for instance the cultivated ground, woods, vineyards, and rivers, &c. The hills are represented in profile with their bases towards the stream; not at all a bad idea, but not to be compared with the present system of plan-drawing, which besides showing the correct distances between objects, is so easy of acquirement, that any one with a little attention would soon be able to make a useful sketch. It is not at all requisite to be an artist, or to draw beautifully; it is of infinitely more importance that correctness of detail and distances should be attended to, with the proper shape and shade of the hills; to put into the plan everything that may be of use for a military purpose, and not to fill the paper with a quantity of useless minutiæ, with the view of making the sketch look pretty, perhaps defeating the object for which it is made, and puzzling the officer who has to be guided by it. I may here remark that in my opinion every officer in the army ought to know something of the principles of military drawing, for though he may never be called upon to execute a sketch, he might be placed in circumstances where the ability to read one correctly, may be of importance.

My intention to-day is to address a few words to you on military drawing and surveying, not with the idea of imparting anything novel, or instructing those well versed in the subject, for very little can be said that has not been written over and over again in many works, but to endeavour to show those not so well acquainted with surveying, the quickest and easiest method of gaining proficiency in an art so essential to a soldier.

Military drawing is the art of delineating on a horizontal plane the irregular surface of the earth; and surveying and sketching, adapting this drawing so as to make a miniature representation of a portion of country to a certain scale.

There are three styles of drawing, rough specimens of which I have drawn: the horizontal, the vertical, and brush-work. The vertical is seldom used in the British army, and brush-work is more adapted for indoor work and finished plans, it is therefore with the horizontal drawing I shall have more to do. It is quicker done, more easily acquired, and as the strokes are at right angles to the watercourses, expresses ground more forcibly than the other styles.

It is impossible, according to any known method of hill-drawing (except actual contouring, of which I will say a few words in the course of the lecture) to express accurately the heights of the different features, and the angles their slopes make with the horizon, it is only by continually studying good models constructed with contour lines marked upon them, and copying the best drawings, that any approximation can be made to reality. Even then, no two individuals ever

agree as to the intensity of shade that ought to be used in a sketch, and it is this which must ever constitute the difficulty of reading correctly a plan, portions of which have been executed by different draftsmen, each with his own idea of shading. The advantage of workmen who are to construct one whole between them, studying in the same school is obvious. To be sure, methods have been invented by different men for showing the heights and slopes of a hill in a survey, such as Major Lehmann's conventional scale of shades; he supposed white to represent the horizontal, and black a slope of 45°, and dividing these two extremes into nine parts, he prepares a different shade for every 5° of slope. This method has not only the objection of the extreme attention required by the draftsman, who has nine different shades to refer to, and must be continually measuring the slope of the hills with a clinometer (a little instrument of which I will presently speak), but it has also the disadvantage of not being able to show the difference between a slope of 45° and a precipitous rock, in fact between a surmountable and insurmountable obstacle. There is also Colonel Van Gorkum's system of normals, but this also has the disadvantage of being complicated, and not adapted to rapid sketching, which, after all, is the aim and object of the military surveyor. I will therefore confine myself to the horizontal style of military drawing, as practised at the Royal Staff and Military Colleges, and in a country peculiarly well adapted for out-door instruction.

The horizontal system of military drawing is a modification of contouring; that is, a number of short, straight, or slightly curved lines are drawn parallel to, or in the direction that contour lines would take in following the sinuosities of a hill or range of hills, the shading to commence at the first contour or water-shed line, and to increase or diminish in depth as the descent is steep or gentle, and to continue to the plain or to the watercourse. By practising from good models and drawings, almost any one, by devoting four or five hours a week for about two months, would gain a sufficient proficiency in the proper touch to enable him to go out field-sketching, which I will proceed to, after mentioning the principal instruments used in military surveying. My time being limited, I cannot enter into a minute description, or explain the method of using them,—any of the works on surveying will show this.

The chief instruments are the

Theodolite,
Box or pocket sextant,
Prismatic compass,
Protractor,
Chain.

Of these without doubt the theodolite is the most accurate, and for a military survey up to about 20 square miles, a five inch instrument on a tripod will be large enough. The theodolite takes both vertical and horizontal angles, the latter without reduction.

The pocket sextant is a useful little instrument, and can be made to read as near as 30″. Though the arc is not generally graduated to more than 120°, a still greater angle may be obtained by using some inter-

mediate object, taking two angles, and adding them together. It must be seen that the instrument is in proper order, the index error (if any) corrected, and that the objects subtending the angle are nearly in the same plane; the sextant will also take a vertical angle by holding it sideways. Although there will be a slight error in the observed angle, on account of the parallax of the instrument if the objects are near; this error decreases as the distance increases, and at half a mile vanishes altogether.

The prismatic compass is the most useful of all instruments for a military sketch, and when mounted on a tripod might be read as near as 15′, but this tripod being rather a cumbersome and conspicuous object to carry about, is seldom used now; by holding the compass steadily in the hand with the card vibrating clear of the glass, it can, on a calm day, be read to a degree easily; and even on a windy day, when the card cannot be quite steadied, if the mean is taken between the two extremes of vibration, it will be very nearly correct. The sketcher should know the variation of his particular compass.

The clinometer is a small instrument used for finding approximately the heights of hills, buildings, &c., and with a table of natural sines and tangents attached, this can be done on the ground. To use the instrument, station yourself at the bottom of a hill, or at a convenient distance in front of a building; hold the clinometer to your eye with the upper edge in a line with the top of the hill or building, and read the angle opposite to the piece of string, which is retained in a vertical position by the weight of a small bullet. To find the height of the hill, pace to the top, and multiply into the natural sine of the observed angle, and to find the height of the building, pace to the foot and multiply into the natural tangent, in either case add the height of your eye from the ground.

The different kinds of sketching-cases in use are very numerous, and there is not one that I know of but has some inconvenience; that which I use myself, and have done some hundreds of sketches with, is 14 inches square, and made so that the paper can be fastened either inside or outside the flap. It has also a pocket inside for pencils, knife, protractor, &c. The disadvantage of this case, on account of the smallness of the fastenings, is, that the sketch is apt to be carried away by a tolerably strong wind; but again, on the other hand, if I made the fastenings strong enough to defy the wind, they would interfere greatly with the protractor when the work gets near the edge of the paper. If any one would kindly invent a sketching-case combining the good qualities of all that are in use now, without their inconveniences, he would confer a great boon upon field-sketchers at large.

I will now proceed to field-sketching. Presuming the workman has a tolerable idea of drawing from models, can use the prismatic compass, understands protracting angles, both with reference to the meridian and with any other line, knows the conventional signs or details used in a military plan, as shown in the diagram, he may with this amount of information execute a field-sketch, for which the following instruments will be required:—

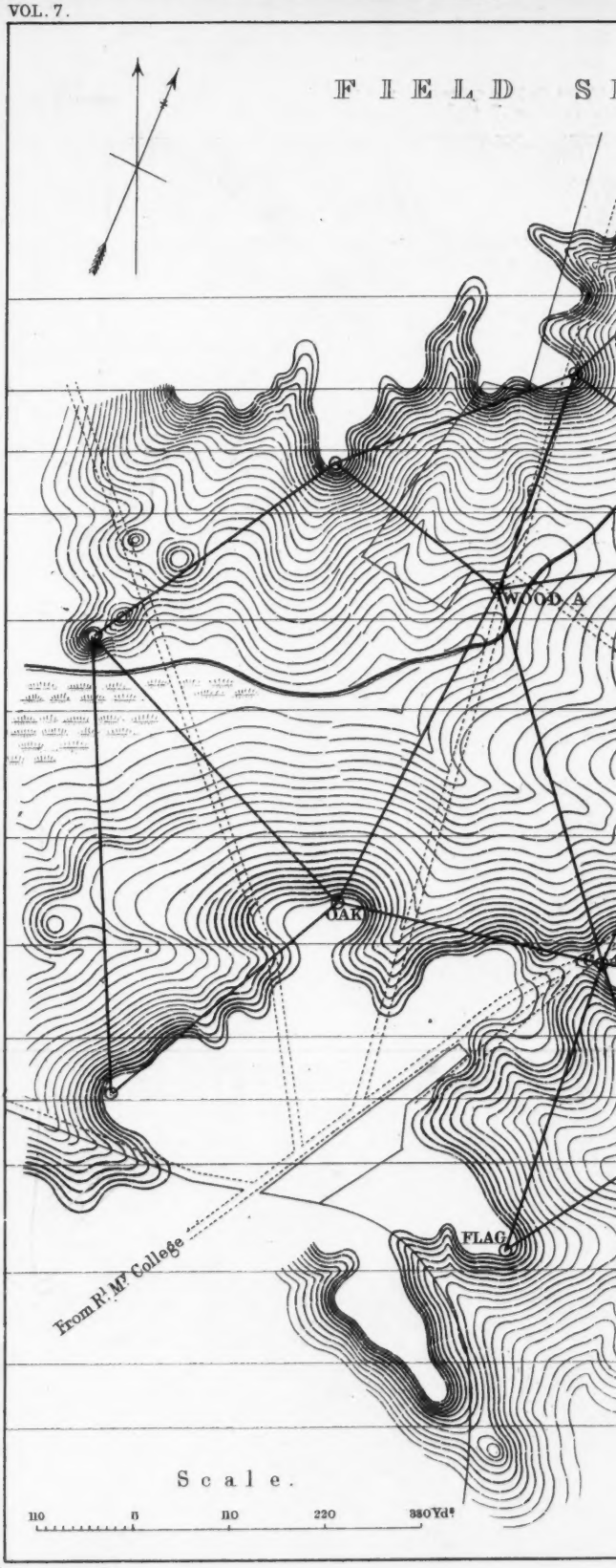
Sketching-case and paper, with parallel lines, at unequal distances, ruled across.

Prismatic compass.

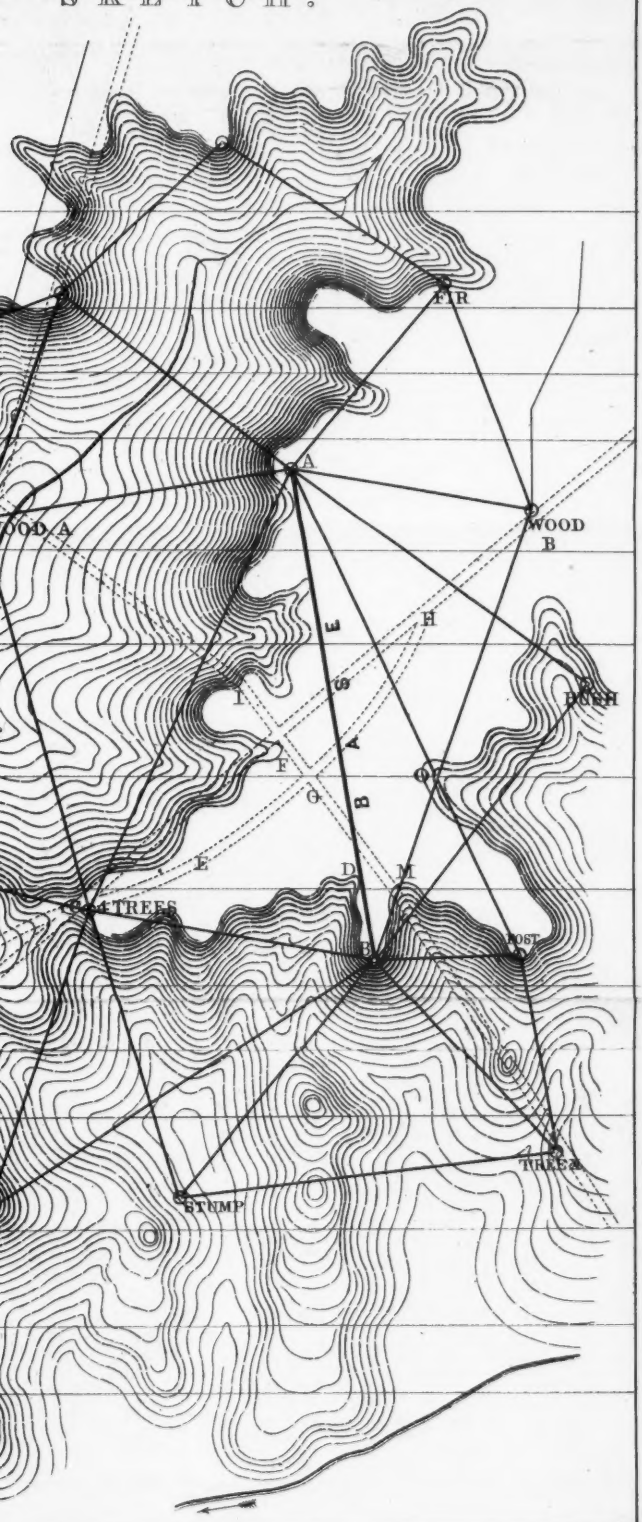
Ivory protector with scale.

Pencils, india-rubber, and penknife.

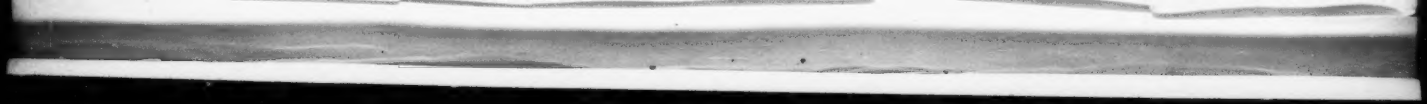
I will endeavour to exemplify the proceedings step by step, by showing the details of an actual sketch of about a square half-mile done by myself, a diagram of which I have brought with me. I select my base A B, for the following reasons, because A and B are both prominent points, and the ground between them is flat; because at A there is a small tree, and at B a post—objects that are likely to be of use as the work progresses—and because from both these points I have a commanding view of the greater portion of the ground comprised in the sketch, a circumstance which greatly facilitates triangulation. Commencing at B, one end of my base, I pace from B to A, and make a note of the distance, viz., 508 paces; being now at A, the other end of the base, with the prismatic compass, I take the bearings of some of the most conspicuous points around me, selecting those that I judge will make good triangles with the base, that is, in which the angles are neither too obtuse or acute (from 60° to 90° are the best); having decided upon the four trees, corner of wood A, brow of hill, fir-tree, corner of wood B, and bush. I take their magnetic bearings carefully with the compass, together with the bearing of the other end of the base; I select a convenient point, A on my paper, and protract all these angles, making the length of the lines for the present indefinite; I now pace back from A to B, which I find this time to be 512 paces, and contrasting this with the first measurement of 508, which shows a discrepancy of 4, I take the mean 510 as the best appoximation to correctness, and lay off that distance from my scale in yards on A B, thereby defining both extremities of the base on paper (while on the subject of pacing I may remark that every one in field-sketching ought to know the length of his average pace, so as to calculate accordingly; my own pace being as nearly a yard as possible, I am saved the delay of reduction). At B also I take all the necessary angles, viz., to all the points observed at A, or as many of them as I can see, and new objects; I find from this place I can see the four trees, corner of wood B, and bush. I therefore protract the bearings of these three, and determine their position by intersection; I also take the direction of the new objects—post, tree X, stump, and flag. As it is a good plan to do as much as possible at a station, to prevent the necessity of returning to it, I commence sketching a little at B, I remark the hill curves round me almost in the shape of a semi-circle, so, judging the breadth at top, I transfer the shape to paper; I next see the re-entering bend at D is almost in the direction of the base; I pace along the base towards A, and measure an off-set of 20 yards at right angles, which gives me the point D on paper, and which I connect by the eye to B, shading off a little way to represent the slope of the hill. Looking now towards the four trees which I have fixed by triangulation, I see that there is a range of features almost on the line joining D and the four trees, so I pace along that line,


FIELD S
WOOD A
OAK
FLAG
From R.t M.r College
Scale.
110
0
110
220
330 Yds

SKETCH.



J.R Jobbins.



putting in the different curves on the way by off-sets, taking care if I leave the direct route for the purpose of taking these off-sets, that I leave some mark on the ground, so as to be able to resume it correctly. I am now at the four trees, and can do a good deal here; having fixed this point by intersection from both ends of the base, I may take the sides C B, C A, as new bases to triangulate on. Consequently, by taking angles at the four trees, I can determine the position of stump, flag, and corner of wood A, and the direction of oak brow, which I fix from wood A when I get there, and in this manner I extend my triangulation until I have a sufficient number of points distributed over my sketch. Before I leave this station and lose sight of the ground I have just sketched, I see if my shading is correct, and in proportion to the steepness of the different slopes, and having once adopted a certain degree of shadow, I must make the little bit I have finished act as a kind of guide and standard throughout the drawing. Standing at the four trees I see the road, which passes close to me, is quite straight up to and beyond the corner of wood B, therefore pacing in the direction of wood A for four paces to get a point on the road, I connect this with wood B, by two dotted straight lines to express a road without hedges; I also take the bearing of the cross road, and pace as far as E, where there is a turning; going back to C, I pace along the straight road as far as F, putting in the different salients and re-enterings on the way (that is, the convex and concave turns of the hills). At F I come to another road, nearly at right angles to the one I am on; with my compass I take the bearings in both directions, and pacing to I, the brow of the plateau, I find the road takes a turn, which I put on paper by the aid of the compass. I also take an off-set at right angles towards the brow on my left, which I connect by the eye to the points F and I; returning to F, I pace along the road towards M, putting in the road G E, G H on the way, by merely joining the points G and E, and taking an angle from G to H; when I come to the point M, I find there is a steep re-entering, and that the road takes a slight turn, I connect the re-entering to B by the eye, and lay off the direction of the turn with the compass, and pacing off to post, taking care to put in everything on the way, I complete my sketch so far. Standing at post, I see the next curve of the hill is in the prolongation of a line joining stump and post, I take advantage of this, and pace in that prolongation to the fall of the hill, sketching it in without the necessity of using my compass. Walking off to the point O, I interpolate, that is, find my position on paper in the following manner:—I look around me for some of the triangulated points, and fix on two which are near me, and from which, straight lines will form a good angle (in this case, bush and post seem the best). I take the forward angles to these points with my compass and lay off the back angles, or angles diametrically opposite from them on paper, the intersection of these lines will give me my position, which, having found, I connect the shape of the intervening ground to where I last was. In somewhat similar manner I proceed with my sketch until the paper is filled; interpolating at important places, occasionally pacing in the

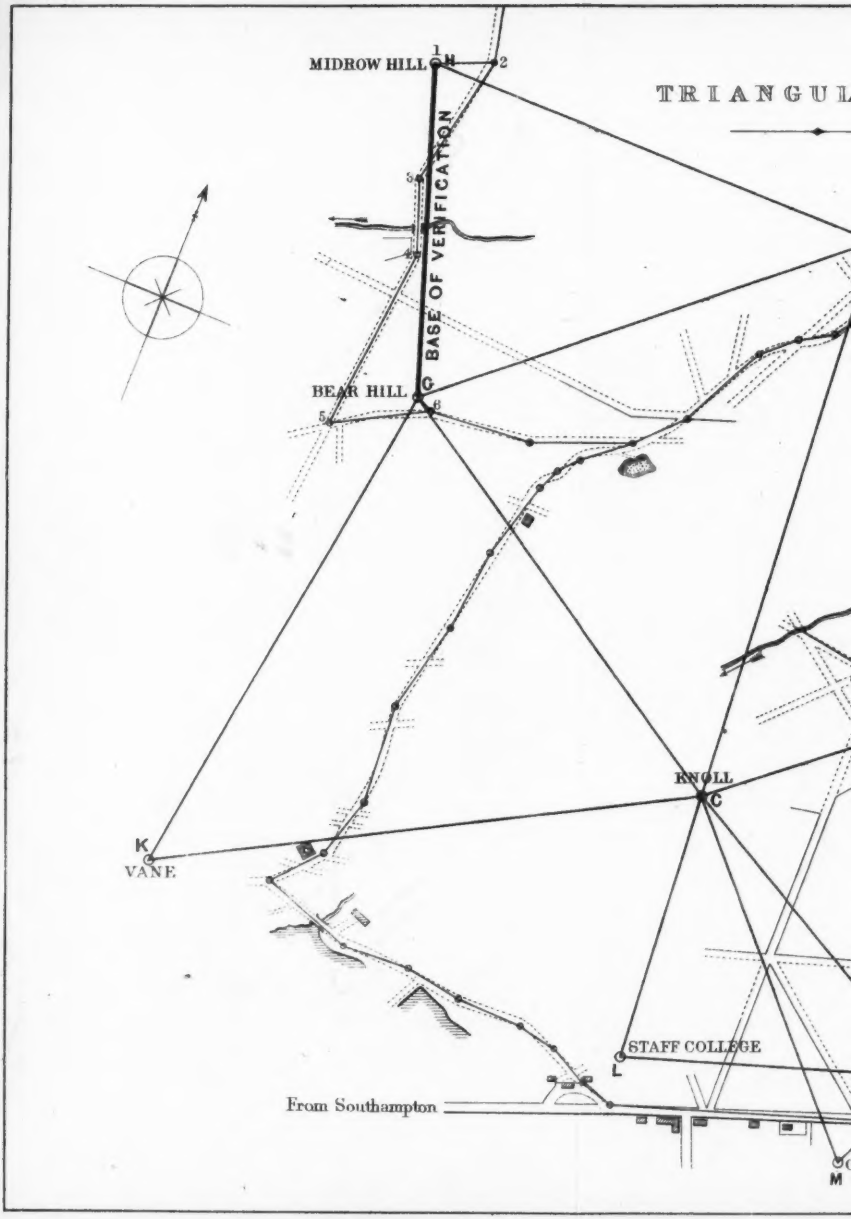
direction of fixed points, sometimes taking bearings and pacing in their direction, and now and then judging short distances, but always working from triangulated points as much as possible, so as to avoid accumulated errors, which must necessarily accrue in measuring by the pace. I do not think I need detain you any more with this subject; of course practice, as in everything else, will make perfect; correctness of eye, and a good judgment of distances are of much value. A scale, and north point (both magnetic and astronomical) should invariably be added to the sketch. Some little difficulty will occur at first in joining the under features or lower spurs neatly to the upper ridges. Seldom or never do we find isolated hills; some way or other we shall find what we fancied at first, single mounds, to have a connection with the neighbouring elevations.

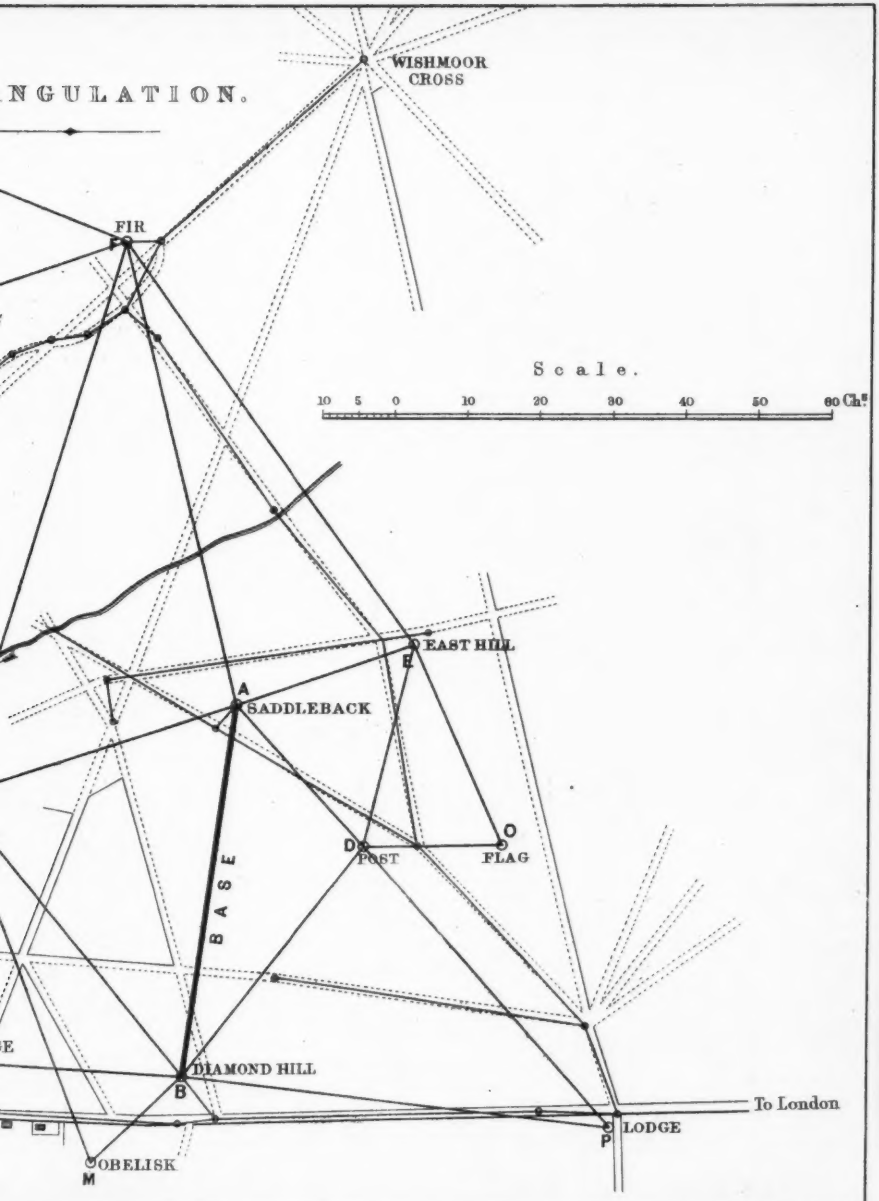
I will now give a short description of the method of conducting a military survey, which, in principle, is somewhat the same as field sketching, inasmuch as a base is measured and triangulation performed, but much greater accuracy is required, more perfect instruments used, and instead of pacing the base, it is accurately measured with a chain or other instruments. I do not presume to treat of national undertakings, like the Ordnance Surveys of Great Britain and Ireland, which are very seldom required, but will speak of military surveys of much smaller proportions, say from about 4 or 5 square miles up to about 15 or 20. For surveys of these dimensions, a base from about three-quarters of a mile up to 2 miles carefully measured with a chain two or three times would be sufficient, supposing the chain itself to have been compared with standard measure both before and after the measurements, and the links counted. The inequalities of the ground, if any, should be reduced to the horizontal, though especial care ought to be taken to select ground as level as possible.

In a primary series of triangles, all the angles should be observed, and the condition most favourable to the accuracy of computation is that in which each triangle is nearly equilateral. When two angles only are observed, as is frequently the case in a secondary series of triangles, the unobserved angle ought to be nearly a right angle; if much smaller or larger, ill-conditioned triangles are formed, which must always be avoided.

If it should be more convenient to take the angles previous to measuring the base, the sides of the triangles may be calculated from an assumed base, and afterwards corrected in the proportion of the assumed to the subsequent measured base. All observed angles are essentially spherical, but when the sides of the triangles do not exceed more than 4 or 5 miles in length, we may consider the angles as rectilineal, and compute the triangles by plane trigonometry; the three angles together ought to be equal to two right angles, if not—and the error is great—the angles must be observed again; if small, the increment or decrement must be equally divided among the three angles, so as to make the sum equal to 180°.

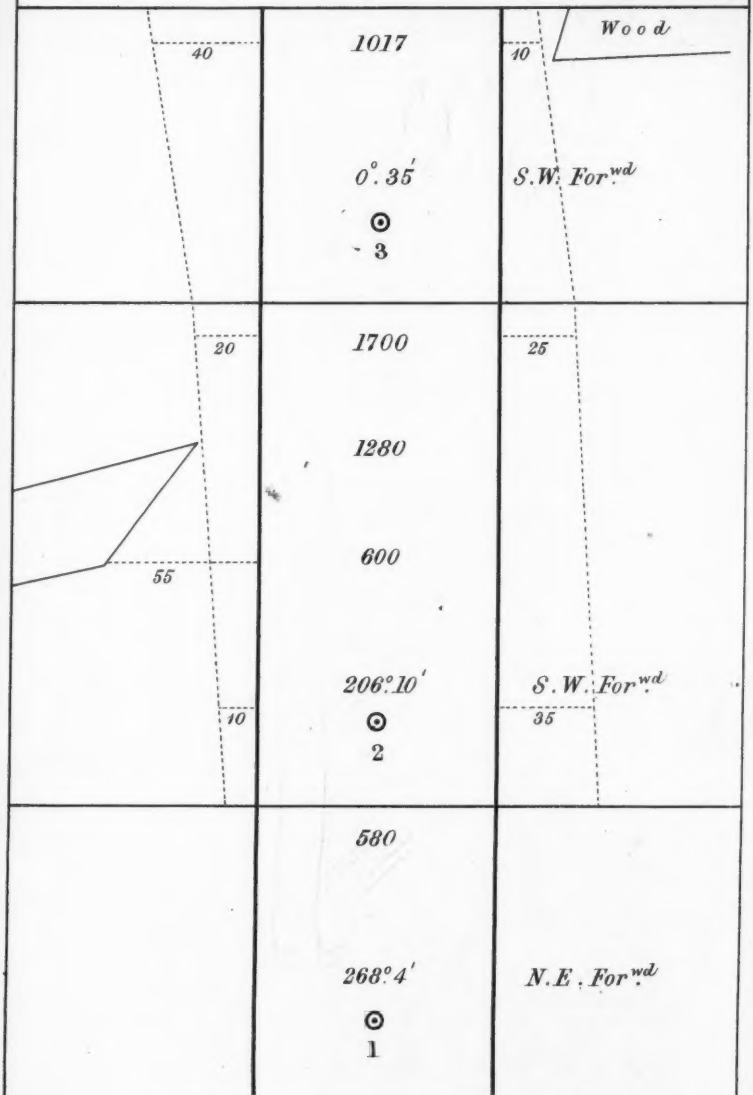
This diagram is an outline of a survey of about 4 square miles done by myself last year near Sandhurst. Having chosen my base A B for the same reasons that I have previously mentioned in field-sketching,


MIDROW HILL
1
2
TRIANGUL
BASE OF VERIFICATION
BEAR HILL
5
6
KNOLL
K
VANE
STAFF COLLEGE
L
From Southampton
M


NGULATION.
WISHMOOR
CROSS
FIR
Scale.
10 5 0 10 20 30 40 50 60 Ch.s
EAST HILL
E
A
SADDLEBACK
D
POST
O
FLAG
BASE
DIAMOND HILL
B
To London
LODGE
P
OBELISK
M

J.R.Jobbins

FIELD BOOK.



Commence at Midrow Hill,
21st October 1862.

J.R.Jobbins.

except that as there was not any defined object at B, I put up a small banderol, or small flag, temporarily.

With my theodolite I observed angles at A, B, C, D, E, F, and G, and by the help of plane trigonometry, I calculated the length of the sides of the triangles A B C, A B D, C A F, &c., according to the formula in the annexed diagram; and in the triangle G H F, the one most remote from the base, I measured the side G H to compare with the same computed; this measurement is called a base of verification, and ought to be resorted to occasionally to check the work, especially in extended triangulation. In my case the measured and computed line G H, which is over 1,000 yards, differed by 5 links, which is about as much as a good long step, not a very great deal in a rough survey, but too much if for any important object. Very little trigonometry is required for the computation of rectilinear triangles, with a little tact all the complicated problems can be avoided, and the solution confined to the first and most simple, viz.:—The sides of triangles are to one another as the sines of the opposite angles, and indeed I find more reliance can be placed on this than the others. Having computed my triangles, and tested their accuracy by a base of verification, I can lay them down on paper to any scale. The scale you see before you is 24 inches to a mile, equivalent fraction $\frac{1}{2640}$, that is, the actual country is 2,640 times larger than the map. The next thing is to traverse the roads, for the performance of which the following instruments are required:—

1 theodolite,
1 chain and 10 arrows,
2 banderols,
1 rod for measuring offsets,
Ink-bottle and pens,
Field-book with blotting-paper,

together with two assistants to chain.

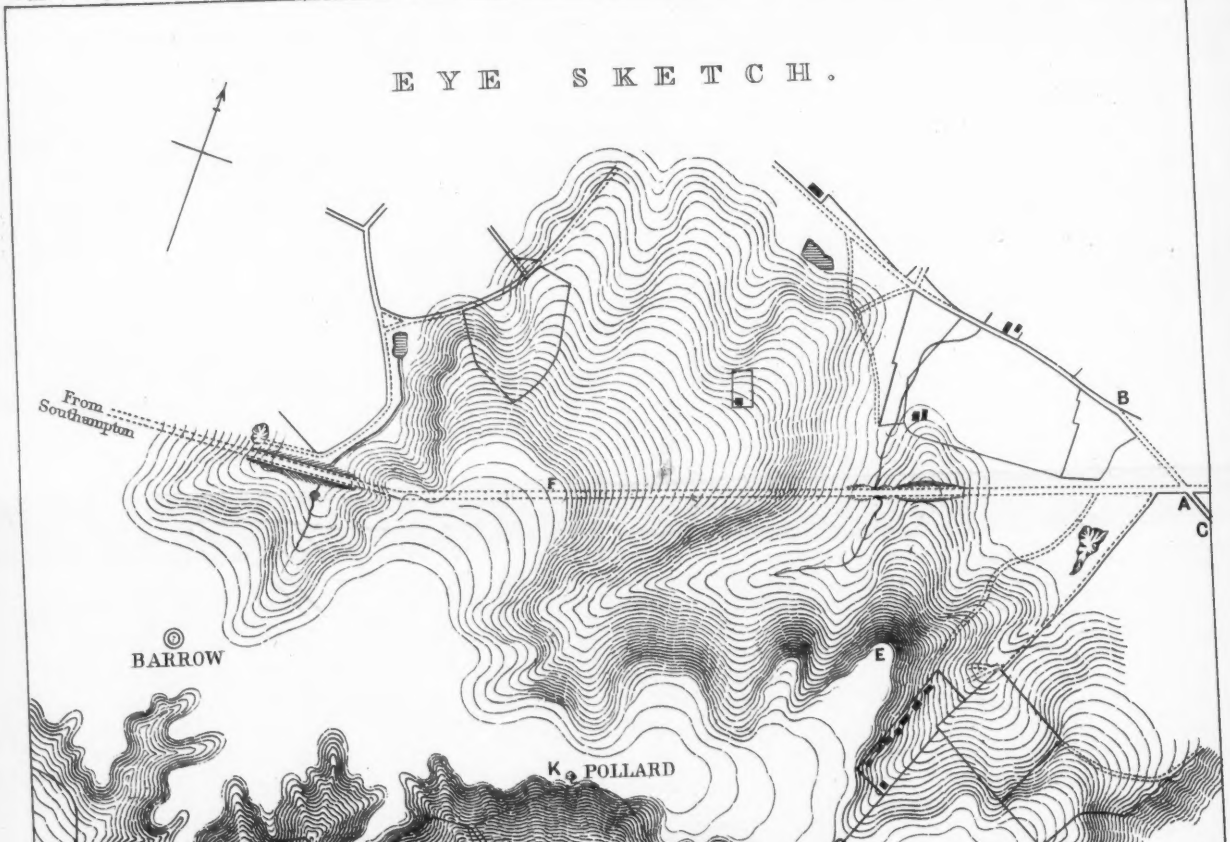
The diagram will show how a field-book is kept, commencing at the bottom and working upwards. The two parallel lines represent the chain from which the offsets are always taken. I may commence traversing at any of the triangulated points I find most convenient; suppose I say at Midrow Hill or station 1, as I will call it in the field-book and plan. Having set up the theodolite exactly over the station, by using a plummet or dropping a stone, I level and arrange it so as to take the first angle with reference to the magnetic north, to the little flag which I place at the point 2, where the nearest road takes a turn; after the angle is taken, which appears to be 268°·4′ N.E., the distance is measured with a chain and entered in the field-book in links, as in the diagram. Leaving one of the flags at station 1, I take the theodolite on, and level it at station 2, pulling up the flag and sending it on to station 3, where the next turning of the road is. After the 1st angle is taken with reference to the north, the services of the needle are dispensed with for the present, the traversing being carried on by the back angle method, which is more accurate than entirely depending on the needle; this latter has many objections, such as insufficient accuracy of adjustment, local attractions, slight variations at different

periods of the day, &c. Proceeding by the back-angle method, at station 2 I look at the vernier on the horizontal arc of the theodolite to see that the last forward angle, viz., 268°·4′ has not been altered during the transit of the instrument from station 1 to 2; I then carefully turn the telescope with the vernier clamped at the above angle, to the foot of the flag which I have left at station 1, taking precautions not to touch the clamping or tangent-screw of the vernier. As soon as I have got the cross wires of the telescope coincident with the bottom of the flag, with the aid of the large clamping and tangent-screws, I make the large clamping-screw tight, which keeps the horizontal arc firm, and which is not moved again until all the angles at station 2 are taken.

By this process it must be evident that I have got the theodolite in exactly the same position at No. 2 station as at No. 1, with the horizontal zeros pointing to the north, which I can prove by loosening the needle and unclamping the vernier, turning the zero of the vernier to the zero of the horizontal arc, and observing if the zero in the compass-box agrees with the north end of the needle. In surveying with a large party I resort to this proof at every station, as I find novices are very apt to turn the wrong screws, unless carefully watched. At No. 2 station I take my angles, reserving the forward one for the last, in order that the instrument may be all ready for taking the back angle from station 3. Before I commence measuring the distance between the 2nd and 3rd station, I take the offsets with my rod, that is, the distance from the chain to the hedges, or the sides of the road, and note them in my field-book as in the diagram. I now chain from 2 to 3 stations, putting down in my field-book any little detail I may come across, such as beginnings and ends of woods, cross-roads, streams, houses, &c., with their approximate position and actual distance from the last station in links, and every time the chainmen have exhausted their ten arrows, 1,000, 2,000, or 3,000, &c. links must be noted down in the book. Particular care must be taken when the arrows are handed from one assistant to the other, to see that the whole ten are given over and received. The theodolite is now brought to No. 3 station and the same process carried on, the flag being taken to No. 4 station. This system however must not go on too far without some check, therefore, when I get to No. 6 station, I will take the forward angle to Bear Hill, which is one of my points of triangulation. I will now cast adrift the back angle, and, taking the theodolite to Bear Hill, I level and arrange it as I did at station 1, and take the bearing of a flag which I placed at station 6, when I took away the theodolite. If I find the bearing agree with the angle I had previously taken from station 6 to Bear Hill, I may conclude my work is so far correct, and continuing thus, commencing my operations always at some triangulated point, and checking them; whenever I come near another, I get the direction and measurements of the roads, which I plot down on paper with either a circular or semicircular brass protractor.

A portion of the outline just done is traced on to drawing-paper and fitted to the sketching-case, at least two of the triangulated

EYE SKETCH.



K. POLLARD
HAWLEY POND
Scale
100 0 100 200 300 400 500 600 700 800 YARDS
J.R Jobbins.

points ought to be in each section, and as the azimuthal deviation of the compass about to be used may not be the same as the theodolite employed for the triangulation, the parallel lines from east to west cannot be drawn until the bearing from one of the triangulated points to another is ascertained with the compass. At some convenient time during the survey, the heights of the principal hills ought to be found, either by trigonometry or levelling from some datum mark, and the result shown on the plan by marking from the highest as No. 1, No. 2, &c., and if there are two or more hills of the same height, they must be marked with the same number; this will show at a glance the relative commands of the various hills.

I have now gone through the different descriptions of military surveying that are applicable to rapid sketching with more or less accuracy. There is yet another method, to which I have previously alluded, of showing hills with mathematical accuracy, but unfortunately exacting an amount of time and labour which can seldom be given; I mean contouring, which is more adapted to engineering purposes than for military surveying. A series of horizontal lines are found with the aid of the spirit level and vane, all over the surface of the ground at equal vertical distances apart, commencing at high-water mark and working upwards. The diagram shows an actual contour sketch of a hill near Sandhurst.

It may sometimes happen that an officer is called upon to make a sketch in a hurry and at a moment when he is unprovided with compass, protractor, or any of the instruments generally required, and difficult as this may appear at first view, it is astonishing how easy it is in practice, and how accurately, comparatively speaking, sketches have been executed by simple pacing and a correct eye; this is called eye-sketching or sketching without instruments. The diagram illustrates a portion of country done by myself in this manner; being furnished with a straight flat rule or lath about a foot long, and having made a scale of paces on a piece of cardboard or thick paper to suit myself, I procured a sheet of plain paper which I fitted to a case (if I had not had a case I would have fastened the paper to a flat piece of wood or old book-cover), and on arriving at the ground, I commence at the point A, where there are cross-roads, and where one runs straight for a considerable distance. I fix upon a convenient point on paper, and draw two parallel lines in any direction I think fit, which I call the road, and the point A my own position; although I draw this at random it will be for the first and last time, for the position of all other roads, points, hills, &c., must have reference to this first road. I now place my paper and case on the ground with the straight ruler coincident with one of the parallel lines, and direct the whole, paper, rule and case, in the direction of the actual road which I can accomplish more effectually by stepping back three or four yards; having got my road on paper in a line with the real road, I take up the ruler (leaving the sketch on the ground) and direct it by the eye towards B, C, & F, in succession, drawing lines of convenient length to represent portions of these other roads. With the ruler I also ascertain the direction of the hill E. I now pace along the road

A, F, to the top of the hill, about 1,300 yards, putting down on my sketch any detail on my way within reasonable distance on both sides of the road, say 100 yards or more, judging the direction and distances by the eye. At the point F, where the ridge of the hill crosses the road, I see that the head of the valley lies between me and the point K, where there is a large conspicuous tree known as the Pollard. I get the direction of the Pollard from the point F, on paper in the following manner: I place my flat rule on the line A, F, and turn the ruler, paper, and all towards the point A, from where I started, this brings my road on paper parallel to the real road, and taking up my ruler, I turn it towards the Pollard, and draw a line. Leaving some mark at F, I pace along the line to the Pollard, putting in the different features on the way, to the right and left of my route within a short distance; arriving at the Pollard, I take the back angle to the mark I left at F., and the forward one to the brow of the hill E, putting down and shading off all the hills and valleys on my way, occasionally taking offsets, if necessary. At E, I can take a back angle at the Pollard, and forward one to O, towards which I pace, sketching in every useful thing on my way, and in this manner I go on until the sketch is finished. In an eye-sketch, one must always know where one is on paper, and a back angle must be taken for the purpose of getting the paper parallel to the country before a forward one can be laid down. The astronomical north can be found approximately by observing the shadow of the sun at twelve o'clock on the sketch, when it has been placed parallel to the ground by some back angle. Of course a scale should be made if there is time.

This kind of sketching will be found of the utmost value in a military reconnaissance, an important duty, usually performed by the Quartermaster-General's department, in which not only must a rough plan of the country be made, but graphic information added in the shape of a report, embracing everything that is likely to be useful to the General, or other officer in command. It is evident that the officer who should be selected for this service, besides being a proficient in Military Surveying, ought to have tact, coolness, and a knowledge of the language or patois of the country he is in. I have not time to enumerate in detail the particulars that should be mentioned in the report accompanying the sketch in a reconnaissance, they should be represented clearly and legibly, the source from which the information is derived must be stated, and nothing entered by guess-work.

It is impossible to epitomise into a single lecture all that can be said on military drawing and surveying, and I fear, much, that I have not clearly explained some of the subjects. In ordinary instruction I find it necessary to elucidate the most simple thing, and never take it for granted that a student must know what appears so easy to myself, but in a lecture this is obviously impossible. If, however, the descriptions I have just given of the various kinds of sketching have afforded the slightest information to any one here present, it will give me great satisfaction.

Evening Meeting.

Monday Evening, June 1st, 1863.

W. STIRLING LACON, Esq., in the Chair.

A FEW NOTES ON THE SWORDS IN THE INTERNATIONAL EXHIBITION.

By Mr. John Latham, Firm of Wilkinson and Son.

In the following short notes on the swords shown in the International Exhibition of 1862, I have of necessity confined my remarks to such peculiarities of pattern or workmanship as could be ascertained by simple inspection, which was all that was possible in the Exhibition, without any attempt to express an opinion as to those qualities of temper or comparative excellence, which could only be decided by an actual trial. The temper of a sword-blade is the most important part of it to the user, but this quality is precisely the one to which no clue is afforded by its appearance in a glass case, or even by simple handling and inspection. A comparative trial is necessary to afford any guide in this respect, and I believe such a trial was at one time contemplated by the jury of Class XI, but this idea was abandoned, for the reason that it would be obviously unjust to the manufacturers to subject their weapons to any experiment, the nature and extent of which had not been previously stated and explained to them. Another objection was that in all countries where the sword is regarded as a weapon to be used and is not manufactured only for sale, or worn merely for the sake of appearance, the temper as well as the shape is determined by the method of swordsmanship adopted, and it would therefore be useless to expect any ordinary blade of European manufacture to compete in hardness of edge with the Asiatic swords; and on the other hand, these would certainly be broken or spoilt by testing them for the elasticity or springing qualities, for which the Toledo blades are so renowned. In fact it was necessary to determine beforehand what were the qualities which should constitute a well-tempered blade, and as each manufacturer would probably have his own notions on this subject, he would naturally object to have his handiwork tried by an unaccustomed standard. For similar reasons, whenever I have occasion in these remarks to refer in any way to the temper of the sword-blades noticed, I shall confine myself to those qualities which

are well known and recognised as characteristic of the national manufacture.

On the English side some very elegant presentation swords were shown in Class XXXIII, as articles of jewellery; but in Class XI, as small arms, there were only two exhibitors, and as my own firm was one of these, I am naturally precluded from making any remarks upon them.

On the foreign side swords were exhibited by Italy, France, Prussia, Spain, and Russia; a few very interesting specimens from Turkey and India; one, the first ever manufactured in a British colony, was shown by New South Wales, and some blades which I shall have especial occasion to notice, were contained in that storehouse of novelty—the Japanese collection.

No doubt you all remember the magnificent weapon which faced the entrance of the Italian Court, and divided the attention of the public with Sig. Monti's famous statue of the Reading Girl, which stood nearly opposite. If you had an opportunity of inspecting it—no easy matter at most times, from the crowd which choked the narrow space—you would admire the graceful outline of the cross hilt, and the elaborate and appropriate ornamentation of every inch of its surface. If you had any experience in the difficulties of metal work, this elaboration would have especially arrested your attention, as it did mine, and you would have been as much surprised as I was to learn that neither casting, chasing, nor engraving had been employed in its production. It was literally built up of distinct pieces of metal in the same way that we build a house of separate bricks or stones, and every minute ornament was separately finished and soldered into its place. This peculiar style of workmanship is the same as that employed in the ancient Etruscan ornaments and jewels, and the sword was the production of Signor Castellani, whose labours and successful revival of this ancient manufacture are well known.

Another sword shown by Signor Rinzi, of Milan, I should especially notice, for the way in which a considerable difficulty had been overcome. In designing a sword-hilt we are often puzzled to know how to manage the grip or handle of it, so as to harmonize with the outline of the guard and yet to avoid any sharp angles or ornament which would render it unsuitable for use as a weapon. In this sword the grip has a full length figure of Italy, in silver, standing with folded arms, and crowned with a large emerald encircled with pearls and rubies. Very pretty and graceful as an ornament, and yet perfectly serviceable as a handle for use.

In France, one large case of swords was shown, containing a very numerous and varied collection, which were especially noticed by the jury for the beauty and artistic taste of their mountings. Another characteristic of the French swords was the excellent way in which they were balanced—a point of great importance in the use of the weapon, and one which is rarely attended to as it should be. The majority of the blades, however, were of German (Solingen) manufacture, only a few being from Klingenthal, and St. Etienne. One novelty shown in this case was the use of aluminum for hilts

and scabbards. The extreme lightness of this metal renders it very suitable for the mounting of dress-swords, but unless considerably alloyed, it is too brittle for a service weapon.

In speaking of the manufactures of Solingen (Prussia), I should first notice the very beautiful sword exhibited by M. Lüneschloss, and presented by him to the present king of Prussia, on the occasion of his coronation. It is a most elaborate work in chased steel, and was wholly designed and executed by Herr Klaucke, who is, I believe, a working artisan at Solingen, and, with the exception of a little stiffness and angularity in the outline of the scroll-work and arabesque ornament, it will bear comparison with many of the mediæval specimens of metal-work, especially if we take into consideration the refractory nature of the material in which the artist has to work. The worker in gold, silver, or brass, can realise his design in the wax model while the idea is fresh in his mind, and the casting will faithfully reproduce every touch of his hand, but the artist who aspires to produce a finished work in steel, is hampered at every step by the refractory nature of his material. An immense amount of laborious toil with the hammer, chisel, and file is necessary, before he can produce the merest outline of the form he desires, and in the finishing, every detail must be obtained by repeated and painstaking labour. On the hilt of this sword there are two figures, each rather more than an inch in height, representing Borussia presenting the sceptre of her realm to the king, and in each of these figures every detail of face and dress is finished in a manner so minute that it can only be appreciated by examining them with a magnifying-glass. At the same time it is a question whether this microscopic detail, however wonderful, is characteristic of the highest Art. In some of the finest works of this kind by Benvenuto Cellini, we find a greater effect produced with far less labour. The different textures of flesh, armour, &c., are discriminated sufficiently by mere rough cuts with the chisel, which give greater form and expression than the laborious finish with the file and graver.

A great number of specimens were shown by Solingen, but with a keen eye to business, these were principally copies of English and French regulation patterns, and the only noticeable feature about them was the extreme lowness of the prices attached. A light cavalry sword, with iron hilt and scabbard, can be made as low as four shillings and threepence; with brass hilt and leather scabbard, at five shillings and ninepence. Of the quality, I will say nothing. This wonderful cheapness is produced by a system of organisation and subdivision of labour. The forging, hardening, and tempering of the blades, the grinding, polishing, &c., instead of being combined in one manufactory as with us, are each separate crafts. But it is a great question whether this system, though it undoubtedly lessens the cost of production, and ensures a certain level of workmanship, has not a tendency to repress any improvement in the quality. Whether you purchase your arms of A. B. or C., they will be the production of the same men, and will have passed through the same hands at every stage but the last, while the man whose name they bear, and who is responsible for

their quality, is precisely the one who has the least control over the details of their manufacture. As an instance of this, the metal generally worked at Solingen for sword-blades, corresponds very nearly to what we call in England, single shear steel, which is soft and easily worked, and though many attempts have been made to introduce a metal better fitted for the purpose, such as double shear or cast steel, they have hitherto failed, because it gives greater trouble to the forger.

A collection which should contain specimens of ALL the different patterns of blades made at Solingen would be highly interesting. Solingen supplies a greater variety of markets than any other manufacturing town, and among other places, Abyssinia, the African Coast, &c., take yearly a considerable number of sword-blades. Now the natives in these parts can hardly be suspected of any antiquarian enthusiasm, but they are nevertheless well acquainted with and thoroughly appreciate many of the best known forge marks and mottoes of the early armourers, among others those of Andrea Ferrara and the old Toledo masters; the Scissors mark of Domenicho Sanchez, the Wolf or Fox of Julian del Rey, the Crown and Cipher of Lupus Aguado, and especially the Sun and Moon of Juan Martin. In fact no blade is considered worth looking at unless it bears a well known mark, and as the original proprietors of these insignia are obviously unable to supply a demand arising a few centuries after their death and burial, the German manufacturer very practically solves the difficulty by putting these marks on his own blades. In a German pattern-book intended for the South American and African trade, I have seen the oddest possible jumble of old acquaintances. Andrea Ferrara, of course, is the most prominent; "God bless the King and the Duke of York" comes next; the third is grave and sententious, "Gravidad, Lealdad y Timor di Dios;" and the fourth blade recommends the purchaser, very probably a naked African, to whom a scabbard to his sword is as unknown as a coat to his back, "No me sacas sin razon, no me envainas sin honor,"—"Draw me not without cause, sheath me not without honour!"

But unfortunately a few of these blades find their way into the European market, and into the hands of dealers not so candid as the manufacturers of Solingen, who, if they imitate the old marks, at least do not attempt to conceal the fact that their blades are of modern manufacture. You may remember the fine collection of reproductions of ancient arms and armour in the French Court, which showed how exactly the characteristics of ancient work can be imitated. It only remains to imitate the corrosion of age, and we have a branch of manufacture which I am sorry to say is alive and flourishing much nearer home than either France or Germany. The way by which these modern specimens are converted into genuine antiques is very simple, and I may as well give you the formula, for the benefit of collectors, who may thus enjoy the pleasure of laying down and maturing their own specimens of arms in the same way as they do their cellars of wine. One advantage of this plan will be that as the collectors generally understand their subject much better than the dealers of whom they

now purchase, they will do the work better, and give the correct appearance of age to their specimens. It is unsatisfactory, to see a "genuine" sword-blade, some three centuries old, but with the hammer and file marks as fresh as if it had been made yesterday; or a blade of the last century, with the signs of four centuries' rust and wear. The first step in the process is to plant your sword-blades in the ground, point upwards, and with a common watering can and rose give them a good sprinkling of sulphuric acid and water. When this has been allowed to eat into the steel for a day or two they are simply buried in a good moist dunghill, where they are kept according to the age required. This varies somewhat with the temperature, but a week for a century is a fair average. When disinterred, the "rust of ages" should on no account be rudely disturbed, but a very gentle friction with a solution of the chloride of antimony on a bit of washleather will give the necessary gloss and depth of colour. A coating of oil completes the process.

To return, however, from this digression to the manufactures of Solingen, the material employed is, as I said before, much softer than English cast steel, and these blades are likely rather to bend than break when subjected to a severe strain. Many of the specimens shown were marked "*Eisenhauer*,"* meaning that they would cut iron without injury to the edge. This is also a quality of some of the old Damascus blades, and any sword-blade of fair temper may be prepared so as to do the same thing. It is only necessary to give it a very thick and burnished smooth edge, and it may be tried on metal without injury, while the same sword with a sharp cutting edge would be instantly notched on contact with metal. Of course a sword with this kind of edge is useless for any soft material, in fact it will cut iron and butter, and nothing else. And here I may notice an ingenious instance of *the art of putting things*, which I lately met with. In an account of the trial of some sword-blades, it was stated that they "severed a cylinder of iron two-tenths of an inch in diameter, without injury to the edge." I have here a cylinder of iron of similar diameter, but I must confess that had I been asked to describe it, I should have employed the undignified title of "*a bit of iron wire*." I will show you how a common cutlass with a suitable edge will cut iron without injury. (The lecturer here cut some pieces of iron wire, and iron plate to the depth of 6 and 7 inches).

I now come to speak of the productions of Spain, "The land of old renown," to which belongs the honour of being the first in Christendom to produce weapons and swordsmen able to contend against and overcome the warriors of the east, and the renowned blades of Damascus. When we read the chronicle of Ruy Diaz the Cid Campeador, or the mighty deeds of Francesco Gonzalez; in these tales of old romance, "The Man and Steel, the Soldier and his Sword," seem inseparably connected, and for this reason alone the

* The name of King Arthur's famous sword has the same signification:—"The name of it sayd the lady is *Excalibur*, that is as moche to say as cut stele."—Morte d'Arthur lib. ij. cap. iij. Caxton's Edit. 1485.

display of the Royal Manufactory of Toledo possesses a special interest. Probably very few of the visitors to the last Exhibition noticed the display of arms from Toledo. They were arranged in the fore part of the Spanish Court, as a sort of background to sundry specimens of rifled cannon and projectiles, which, from their greater bulk, almost hid them from sight. The collection, however, was not equal in variety to that of the Exhibition of 1851; but though less rich in the character of the specimens, it was very interesting, consisting of a complete series of the regulation swords in use in every branch of the service of Spain; also some few of the rarer Moorish forms were shown, covered with elaborate ornament. The shape of the blades preserved one peculiarity which sprang from, and illustrates the principle of the old Spanish school of swordsmanship, which is the foundation of all our modern European systems—I allude to the thick rounded edge of the "fort" of the blade where it is employed for parrying or guarding. There was great variety in the shapes and mountings of the swords exhibited, which were calculated according to the kind of service for which they were intended, instead of adopting, as we do, one regulation form for every service, whether to be used on foot or on horseback, or on the deck of a ship, whether by a powerful or weak man, the English regulation recognises no difference, but prescribes the same kind of weapon for all.

The temper of the Toledo blades has long been famous in history, and they have been especially renowned for their flexibility, in which quality they are supposed to excel the blades of any other country. We may easily conjecture how this impression arose. These blades were, centuries ago, the only European ones which could be compared with those of Damascus and the East for quality, and in comparing the two this very flexibility would be the distinctive quality which would first arrest attention, the Damascus blades being, both from their shape and temper, completely inflexible. The reputation thus acquired has lasted to the present day, though neither the modern nor the older Toledo blades will stand springing any better than most European steel of good temper. Among the Toledo blades shown at the Exhibition, was a model of a Spanish infantry officer's sword, the blade of which was bent round, so that the point touched the hilt, thus describing a complete circle. This sword was of course useless for any practical purpose, the blade being very thin, but as an illustration that such toys can be made in England or anywhere else if there is a demand for them, I have here a sword which, as you will see, forms a waist-belt also, the hilt clasping round and fastening to the point. I can wear it in this fashion without any inconvenience. I have made a similar sword for dress purposes for an officer travelling on the Continent, in order to avoid the inconvenience of a long package; this sword *and its brass scabbard also*, folded up so as to pack inside an ordinary hat-box.

The following interesting passage is extracted from the last edition of Borrow's "Bible in Spain:"—

"In old times, as is well known, the sword-blades of Toledo were held in great estimation, and were transmitted as merchandize throughout Christendom. The

present manufactory, or "fabrica," as it is called, is a handsome, modern edifice, situated without the wall of the city, on a plain contiguous to the river, with which it communicates by a small canal. It is said that the water and the sand of the Tagus are essential for the proper tempering of the swords. I asked some of the principal workmen whether, at the present day, they could manufacture weapons of equal value to those of former days, and whether the secret had been lost.

"'Ca,' said they; 'the swords of Toledo were never so good as those which we are daily making. It is ridiculous enough to see strangers coming here to purchase old swords, the greater part of which are mere rubbish, and never made at Toledo; yet, for such, they will give a large price, whilst they would grudge two dollars for this jewel, which was made but yesterday.' Thereupon, putting into my hand a middle-sized rapier, 'Your worship,' said they, 'seems to have a strong arm; prove its temper against the stone wall: thrust boldly, and fear not.'

"I *have* a strong arm, and dashed the point with my utmost force against the solid granite; my arm was numbed to the shoulder from the violence of the concussion, and continued so for nearly a week; but the sword appeared not to be at all blunted, or to have suffered in any respect.

"'A better sword than that,' said an ancient workman, a native of old Castile, 'never transfixed Moor out yonder on the sagra.'"

With all deference to Mr. Borrow's judgment, I cannot help thinking that such a method of proof was much more calculated to try *his* temper than that of the sword-blade. The trial of the blade upon a stone wall recalls the passage in the old chronicle of Roland, attributed to Archbishop Turpin, where Roland, grievously wounded, descends from his horse, and, after addressing his sword in terms of the greatest affection,* endeavours to break it to prevent its falling into the hands of the accursed Saracens. To effect this he delivers three tremendous cuts upon a block of marble, but instead of the blade being broken, the marble is cut in half by the blow and the sword so deeply embedded in the earth that he cannot withdraw it.

The method of testing sword-blades employed at the Royal Manufactory of Toledo, consists in striking by the hand the back and edge of each blade upon a block of hard wood or iron, springing to a definite standard and striking the flat side upon a curved surface. These tests very much resemble the Government proof for privates' blades in England. The limited space will not allow me to illustrate them here, but I shall be happy to show and explain them to any one who will favour me with a call at Pall Mall.

The display of sword-blades in the Russian Court was especially interesting, not only for the excellence of manufacture and finish of the articles exhibited, but from the valuable explanation furnished by Colonel Anosoff, and translated by Captain James Abbott of the Bengal Artillery. Very fortunately the museum of this Institution

* "Rollant molt blessez dedans le cors descendi de son cheval; e si avait encore s'espée avec lui—la plus bele d'œvre e la mieudre qui oncques fust. . . . . Il la trait d'au fuire e la tint en son poing molt longament e l'esgarda, puis si dist: 'O doce espée, e bele, e avenanz, e lée, e bien trenchanz! De totes la plus terme e la mieudre e la plus vaillanz!—O doce espée ot le poing d'or et ot la croiz dorée.' . . . . . 'O doce espée, ô boneurose espée à laquelle nule ne fu oncques semblanz ni jameiz ne sera! Cil qui te forgia ni avant ni après ne fit oncques si bone, etc.' . . . . . Quant il ot ço dit, por ço que ne chaist au mains dou mauvres sarrasins, si en feri trois fez soz le marbre, car il la vouloit briser; mes rien ne li vaut, car li marbres fendi en does moitiez e l'espèe remest en la terre."

possesses some of the finest specimens of these blades from the Exhibition, which are now upon the table. The steel is made from the Siberian iron-ore and possesses a very fine natural damask, similar in kind but differing slightly from that of the Indian blades. I have placed on the table for your comparison one of these blades, with one of the celebrated Indian blades, known as the Kirk Merdevund, forty ladders, or Ladder of Mahomet, from the number of gradations in the pattern or figure. Also, an artificial Damascus blade, made upon the principle described in Crevelli's work*, and a sham Damask blade of German manufacture, in which the figure is only etched on the surface, but the imitation is so elaborate and painstaking as to deceive any but the very closest inspection. I had intended to illustrate the points of difference in these blades, and to have offered some remarks on the subject of the "*Jowhir*," or watering of the Damascus blades, but I find that the necessary explanations will so far exceed the limits of this paper, that I must defer them to a future occasion. I may say, however, that the workmanship and temper of these Russian blades is most excellent.

I must next call your attention to a pair of Japanese swords, kindly lent me by Mr. Charles Hooper, which, in point of accuracy of workmanship, and finish, excel any specimens of Eastern or European manufacture that I have ever met with. Every part of these blades from point to hilt, is as sharp as the keenest razor, and of a temper so hard that a file will hardly touch them. They have, however, the disadvantage of Eastern swords, that they are very brittle and require to be used with the skill of an Eastern swordsman, or the blade will probably break in your hand. The metal is harder than the best English cast steel, and possesses a slight figure somewhat like that of the Russian blades, as you will see by shading the surface; the hilt contrasts strangely with European notions in its great length and the absence of any guard for the hand. The shorter sword reminds us of the lines of Hudibras—

> "This sword a dagger had, his page
> That was but little for his age."

The resemblance ends here, however, for this weapon is a full grown and promising cadet of a most formidable family.

I have mentioned that these sword-blades have the usual defect of steel so highly tempered as the Eastern blades almost universally are —that is, they are *brittle*. In support of this opinion, I would call your attention to the following passage from Sir Rutherford Alcock's very interesting work, "The Capital of the Tycoon," page 241, where he gives an account of the first of the horrible series of assassinations which mark every step of our progress in this strange land. He relates that three unarmed men from one of the Russian ships were set upon by a party of Japanese and hewn down with the "most ghastly wounds that could be inflicted; two were left in a pool of blood, the flesh hanging in large masses from their bodies and limbs."

* "Sull'Arte di fabricare le Sciabole di Damasco." Milan, 1821.

And further on, though this butcher's work was effected upon men perfectly unarmed, I find it stated that, "a piece of broken sword was found by the bodies." Now a weapon that could be broken in this way, by the mere resistance of an unarmed victim, would be perfectly useless if employed in the European way of cut and guard, where the blade must be elastic enough to withstand the jar of meeting the opponent's weapon at every moment.

These Japanese swords are very expensive, the finest blades, without hilt or mountings of any kind, are said to cost nearly one hundred pounds English. The method of proof is highly practical, but very horrible. The maker or purchaser of a new sword sends it to the public executioner to be tried upon real flesh and blood, and the certificate of this ghastly test, which is generally engraved upon the "tang," adds considerably to its value. From the peculiar hardness and colour of the Japanese steel, as well as the slight "figure" found in it, I suspect it is alloyed with traces of the rarer metals, probably derived from some of the numerous volcanoes in Japan.

I will now conclude with my best thanks for the kind attention you have accorded to me.